The Cunard Liner "Mauretania" passing down the River Tyne.

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The Cunard Express Liner "Mauretania."

Compiled by A. G. Hood and H. Bocler.

The Cunard Company and Atlantic Traffic.

NO recent event in the shipping world has excited nearly so much general interest as the completion and entry upon the Atlantic service of the two new express Cunarders, the *Lusitania* and *Mauretania*. The performances of both vessels have demonstrated not only that in them Britain possesses two ships capable of beating all Atlantic records, but that their superiority in speed is so great that it is not likely to be challenged for many years to come. This success is a crowning tribute to the enterprise which has distinguished the Cunard Line from its inception sixty-seven years ago to the present time.

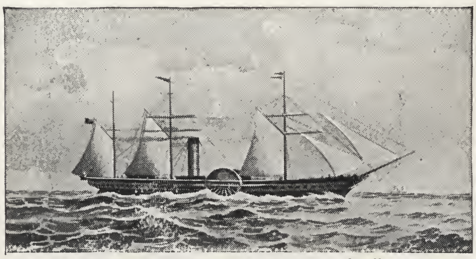


Fig. 1.—The "Britannia."
(First Cunard Liner.)

It is interesting to record that the first Cunard vessel, the *Britannia*, built in 1840, was a wooden paddle steamer 207ft. long, 34ft. 4in. broad, and 24ft. 4in. deep, with a gross tonnage of 1,154 tons and an indicated horse-power of 740. Her cargo capacity was 225 tons, and she carried 115 cabin passengers. Her average speed was 8·5 knots per hour, with a coal consumption of 38 tons per day. When these figures are contrasted with the dimensions of the *Mauretania* and it is remembered that the latter vessel requires a coal consumption of approximately 1,000 tons per day to develop the 65,000 to 70,000 horse-power necessary for maintaining 25 knots' speed, it will be seen what enormous strides have been made since the *Britannia* sailed on her maiden voyage.

The gradual development in size of successive Cunard vessels is shown in Fig. 2, which recalls to mind many notable liners, the company having always kept in the forefront in providing first-class ships. As speed increased, however, with the consequent enormous addition to first cost, the opinion gained ground that large slower speed vessels would afford greater financial success than high-speed liners. After the completion of the *Campania* and *Lucania* in 1893, which, with the exception of the two new vessels, are still the swiftest steamers in the Atlantic trade flying the British flag, the Cunard Company and other British passenger lines adopted this view, and constructed several high-class vessels of what is known as the "intermediate" type, the *Ivernia* and *Saxonia* built in 1900, the *Carpathia* built in 1902, and the *Caronia* and *Carmania* built in 1905, being notable

examples; and it was temporarily left to the German lines to carry on the development in speed. Table I. shows the excellent progress made by the Germans in this respect.

TABLE I.—LARGE ATLANTIC LINERS.

Name.	Builders.	Date.	Length.	Breadth.	Depth.	Draught.	Displacement.	Gross Tonnage	Engines.	I.H.P.	Speed.
			Ft.	Ft. in.	Ft. in.	Ft. in.	Tons.			—	Knots
Great Eastern ...	Scott Russell	1858	680	83 0	57 6	25 6	27000	24360	Paddle & Screw	7650	14·5
Paris and *New York*	Clydebank Works	1888	528	63 0	41 10	23 0	13000	10499	Reciprocating	20600	21·8
Teutonic and *Majestic*	Harland & Wolff	1890	565	57 6	42 2	22 0	12000	9686	Do.	19500	21·0
Fürst Bismarck ...	Vulcan Co., Stettin	1891	503	57 3	38 0	22 6	10200	8000	Do.	16412	20·7
Campania & Lucania	Fairfield Co.	1893	600	65 0	41 6	23 0	18000	12500	Do.	30000	22·01
St. Louis and *St. Paul*	Cramp, Philadelphia	1895	536	63 0	42 0	26 0	16000	11629	Do.	18000	21·08
Kaiser Wilhelm der Grosse.	Vulcan Co., Stettin	1897	625	66 0	43 0	28 0	20880	14349	Do.	30000	22·5
Oceanic	Harland & Wolff	1899	685	68 5	49 0	32 6	28500	17274	Do.	27000	20·72
Deutschland	Vulcan Co., Stettin	1900	662·9	67 0	44 0	29 0	23620	16502	Do.	36000	23·5
Kronprinz Wilhelm ..	Do.	1901	663 o.a.	66 0	43 0	29 0	21300	14908	Do.	36000	23·5
Kaiser Wilhelm II. ...	Do.	1903	678	72 0	52 6	29 0	26000	19361	Do.	38000	23·5
La Provence	St. Nazaire Works	1906	597	64 7½	41 8	26 9	19160	13750	Do.	30000	22·05
Kronprinzessin Cecilie	Vulcan Co., Stettin	1907	678	72 0	52 6	29 0	26000	19400	Do.	38000	23·5
Lusitania	Clydebank Works	1907	760	88 0	60 0	...	44060*	30822	Turbines	70000	25·5
Mauretania	Swan, Hunter, & Wigham Richardson, Ld.	1907	760	88 0	60 6	...	44640*	31938	Do.	70000	26·0
							*Reg. Displ.				

When it is considered what excellent use can be made of high-speed liners as armed cruisers in time of war, it is not surprising that, early in the present century, there was a strong feeling in this country that the time had arrived for Britain to augment the number of vessels available for such service. It was with this powerful argument in his favour that the late Lord Inverclyde approached the British Government with the object of securing its co-operation in

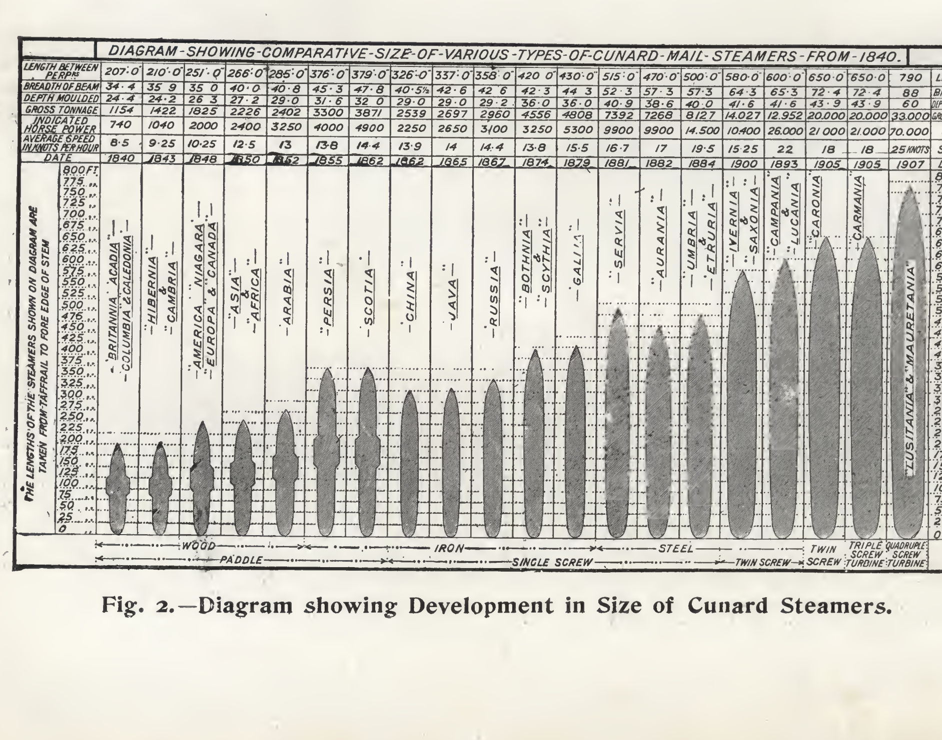


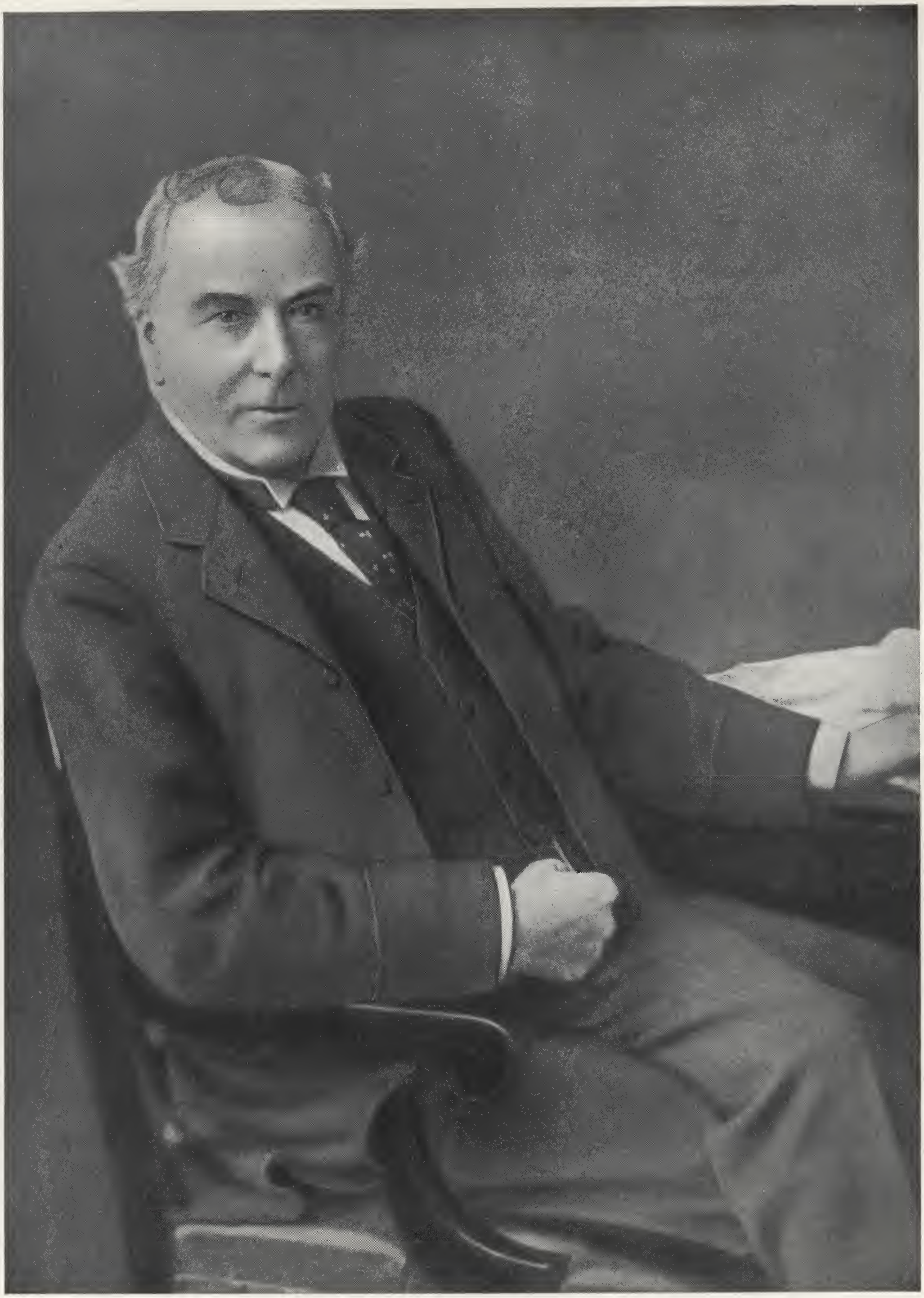
Fig. 2.—Diagram showing Development in Size of Cunard Steamers.

the construction of two new ships of unprecedented speed and dimensions, and, with characteristic energy, carried his project through. It is deeply to be regretted that he did not live to see the culmination of his labours. He was succeeded by the present Chairman of the company, Mr. William Watson, who with his colleagues is carrying on the great work of the Cunard Line with admirable skill and courage.

The conditions laid down in the agreement entered into in 1903 between the British Government and the Cunard Company required the construction of two steamships "capable of maintaining during a voyage across the Atlantic a minimum average speed of from 24 to 25 knots per hour (say 27 to 29 statute miles) in moderate weather." Stringent requirements were stipulated by the Cunard Company in the contracts with the shipbuilding companies as to the speed on trial; but it is to be noted that, contrary to the general idea prevailing, no guarantee of an average speed from port to port across the Atlantic was given or asked for by the owners, it being contrary to their practice to assent to any conditions which would involve the slightest risk to their passengers in thick or stormy weather. The vessels were to be constructed to the requirements of the Admiralty as auxiliary cruisers, and the Government was to have the right to require their services in time of war. In order to meet the cost of the ships, the Government agreed to provide a sum not exceeding £2,600,000 at $2\frac{3}{4}$ per cent. interest and an additional annual subsidy of £150,000.

The late Lord Inverclyde.

The agreement between the Government and the Cunard Co. also stipulated that the line should remain entirely under British control, that all the vessels of the company should be at the disposal of the Government for hire or purchase on terms agreed, and that plans of any new vessels to be built of 17 knots' speed and over should be submitted to the Admiralty for approval.



Mr. William Watson.
(Chairman of the Cunard Company.)

Evolution of the Design.

THE design of the two Cunarders which were going to bring back to England the blue ribbon of the Atlantic may be said to have been seriously taken in hand, so far as Messrs. Swan, Hunter, and Wigham Richardson were concerned, in 1901, when plans were submitted by them to the Cunard Company for a ship 700 feet long to steam 24 knots. The matter was left there until about September, 1902, when it was taken up again, the agreement already referred to having been conditionally arranged between the British Government and the Cunard Company. It was, however, considered that a more decided advance should be made compared with existing ships, and a speed of about 25 knots aimed at.

An outline specification was prepared by the Cunard Company for a ship 750ft. B.P. by 76ft. by 52ft., embodying the Company's requirements with regard to passenger accommodation, etc. This specification formed the basis on which the first estimates were made, and from it was gradually evolved the present ship. Needless to say, the design of a first-class Atlantic passenger steamer, greatly excelling in size and speed anything that had been produced up to that time, involved an enormous amount of preliminary work and research; and a final decision was not arrived at before a good many alternative proposals, emanating either from the Cunard Company or the shipbuilders, had been considered.

At the beginning of 1903 matters had begun to take a more definite shape. The proposals of Messrs. Swan, Hunter, & Wigham Richardson and Messrs. Vickers Sons & Maxim, of Barrow, were considered the most satisfactory and provisionally adopted, and it was generally expected that these two firms would each be entrusted with the building of one of the vessels. Complete plans were prepared, and the Tyneside firm proposed a ship 760ft. by 80ft. by 60ft., while the Barrow firm put forward a design with 2ft. less beam. Both ships were intended to be driven by three sets of tandem quadruple expansion five-cylinder reciprocating engines capable of developing together over 60,000 I.H.P. The two firms having compared the result of their independent investigations in regard to the different problems involved in the design, models of the two proposed vessels were made at Haslar, and tested in the Admiralty experimental tank there. These experiments showed a decided advantage for the broader and somewhat finer ship, which required about 7 per cent. less power to attain the same speed. About the same time Messrs. John Brown & Co., of Clydebank, submitted a proposal for a vessel 725ft. by 80ft., which, however, did not give quite such good results when the model was tested at Haslar as the two just mentioned. It was evident that a long ship with very fine ends was required, but 760ft. between perpendiculars and 790ft. over all were the limits proposed by the Cunard Company, owing to considerations of dock accommodation.

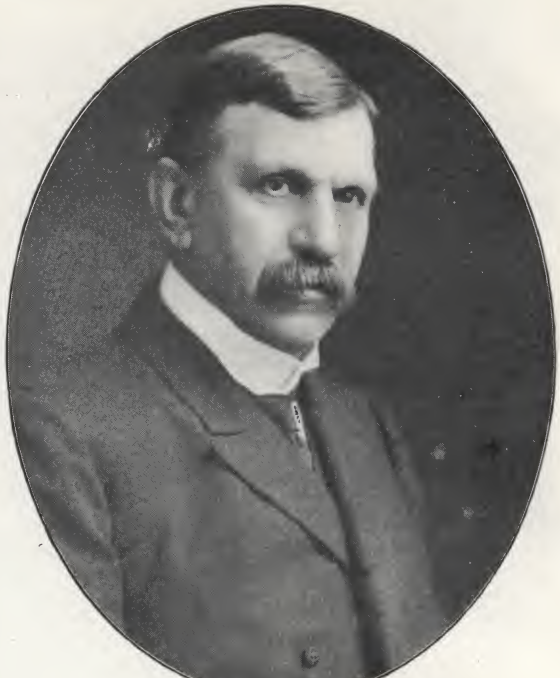
Further experiments were made by Mr. R. E. Froude at Haslar, under the direction of Sir Phillip Watts, to ascertain to what extent resistance could be reduced by an alteration in the lines. Models were tested corresponding to ships of 85ft. and 88ft. beam, the ends being correspondingly fined as compared with the ship with 80ft. beam, the idea, of course, being to reduce the wave-making resistance. As a result of these experiments a complete design was got out for a vessel 760ft. B.P. by 87ft. 6in. by 60ft. 6in. D.M. to shelter deck. A further alteration in the new design was that the working draught of water was increased from 32ft. 6in. to 33ft. 6in., the New York Harbour authorities having decided to increase the depth of New York Channel.

The increase in dimensions made it difficult for the Barrow Company to tender for the construction of the vessels, one of the reasons being that the docking facilities at Barrow did not enable them at that time to deal with ships of such a beam as was being favoured. On the other hand, the Clyde Trustees, having decided to widen and deepen the river so as to enable Messrs. John Brown & Co. to build ships of the proposed length, this firm came forward again.

In August, 1903, the directors of the Cunard Steamship Company, in view of the success achieved with smaller turbine-driven ships, decided to refer the question of the type of propelling machinery to a commission, with Mr. James Bain (general superintendent of the Cunard Company) as chairman, and composed of Rear-Admiral H. J. Oram (representing the British Admiralty), Sir William H. White (Swan, Hunter, & Wigham Richardson), Mr.

Andrew Laing (Wallsend Slipway Company), the Hon. C. A. Parsons, C.B. (Parsons Marine Steam Turbine Co.), Mr. J. T. Milton (Lloyd's Register), Mr. Thomas Bell (John Brown and Co.), and the late Mr. William Brock (Denny Brothers), with Engineer-Lieutenant W. H. Wood, R.N., as secretary. After some months of research and experiment, this commission unanimously reported in favour of the adoption of marine steam turbines on the Parsons principle.

The time occupied by these negotiations, and by the investigations necessitated by the adoption of the new type of propelling machinery, enabled the builders of the *Mauretania* to complete and revise their calculations. The questions of weights, strength, stability, watertight subdivision, steering and docking arrangements, etc., were carefully re-considered, and some very interesting investigations made, concerning which more will be said presently. Special interest also attaches to the model launch, 47ft. 6in. long B.P., which was built at Wallsend and provided with electrical propelling machinery, and with which a long series of experiments were made. These experiments, however, are fully dealt with in the article by Messrs. E. W. De Rusett and M. Wurl published elsewhere in the present issue.



Sir Philip Watts, K.C.B.
(Director of Naval Construction to the Admiralty.)

The Hon. C. A. Parsons, C.B.

Finally, all the main particulars of the ship having been agreed upon by the owners, the shipbuilders, Lloyd's, and the Admiralty, a definite agreement for the construction of the vessel was entered into between the Cunard Company and Swan, Hunter, & Wigham Richardson and the keel laid at the Wallsend Shipyard. Many details in regard to propelling machinery were, however, still in abeyance, and this explains why the photographs taken in the preliminary stages of the construction show a considerable advance in the progress of the work at the forward end of the ship. At the after end the work was somewhat delayed, in order that the position of bulkheads, engine seatings, etc., could be fixed to suit the best arrangements for the machinery which had not then been finally settled. This policy, although it involved some delay in the completion of the vessel, enabled several improvements in the design of the turbines to be embodied at later stages. But for these delays the *Mauretania* would have been completed several months earlier. As it was, she was delivered in Liverpool after preliminary trials a month before the contract date, the time occupied from the signing of the contract to the completion being 29 months.

Investigations relating to Strength, Scantlings, Docking and Stability.

BY PROFESSOR J. MEUWISSEN, M.I.N.A.

BEFORE the scantlings of the new Cunarder were decided upon, some interesting calculations were made at the Wallsend Shipyard with reference to the strength of large Atlantic liners, and we propose to put before readers of *The Shipbuilder* a summary of some of the more important results.

* * * *

Strength and Scantlings.

IT may here be mentioned, for the benefit of those not familiar with the subject, that the problem of determining the exact stresses a ship is subjected to in a seaway is much too complicated to lend itself to purely mathematical treatment. Past experience, gained by the behaviour of ships at sea, must always be the guiding factor in designing a vessel; but by comparing a ship to a girder it is possible to calculate the stresses which would come upon it under certain assumed conditions of loading. Hence it becomes possible for the naval architect to investigate the influence upon the stresses of a change in form and dimensions, and then, within certain limits, modify the scantlings to meet the new conditions.

It is now usual to make the strength calculations of a ship for certain standard conditions, *viz.*, the ship is supposed to be placed in statical equilibrium on the crest or in the hollow of a trochoidal wave having from crest to crest a length equal to the length of the ship and a height from hollow to crest equal to one-twentieth of its length.

Fig. 3 represents one of the stress diagrams of the *Mauretania* under standard conditions. The vertical ordinate intercepted between the curves of weight and buoyancy represents the load at any point, and by integrating these values the curves of shearing forces and bending moments have been constructed. The meaning of the other curves shown will be explained later on.

Several such diagrams were worked out for various conditions of loading, but the one which we publish was found to correspond to the maximum hogging stresses under ordinary working conditions. The ship is assumed to be on the crest of a wave 760 feet long by 38 feet high, and the coal bunkers nearly empty, *i.e.*, the ship is nearing its port of arrival. With bunkers full, the maximum bending moment is less. The maximum sagging stresses occur when the vessel is in the hollow of a wave 760 feet long and 38 feet high, the bunkers being full; but the sagging stresses were found to be smaller than the hogging stresses. Calculations were also made for waves of different lengths, but the foregoing represents the worst conditions. It is very unlikely it will be met with at sea.

The maximum bending moment occurs amidships and was found to be 973,000 feet-tons. The modulus of resistance of the section being 94,500, the maximum stress works out at 10·3 tons per square inch in the top member of the girder. The material in this part being high-tensile steel having a limit of elasticity of 20 tons to the square inch, and a breaking load of about 36 tons, it will be seen that the factor of safety works out at about 3·5, which is more than in most Atlantic liners.

The question of adopting high-tensile steel for those parts of the structure most heavily stressed arose through the desire to effect economy in weight wherever possible. Before deciding upon its use, however, it was necessary to demonstrate that a reliable material could be produced in the form of plates of the great thickness required. Exhaustive experiments were conducted upon samples supplied by Messrs. John Spencer & Sons, of Newburn, who eventually made all the high-tensile steel used

in the *Mauretania* (see the paper read by Mr. E. W. DeRusett before the Institution of Civil Engineers, in June, 1907, and the subsequent discussion*); and it was finally decided to adopt a material having an ultimate tensile strength of 34 to 38 tons per sq. inch, with an elastic limit of not less than 20 tons per sq. inch, for the upper works to the extent shown on the outline profile of Fig. 4 (taken from Mr. DeRusett's paper), and the midship section given in the article devoted to the building of the hull. A reduction of 10 per cent. from the scantlings fixed upon a mild steel basis was sanctioned by Lloyd's Register; but as both the initial experiments and the tests upon the material actually supplied to the ship showed that the ultimate strength was 18 per cent. higher than ordinary mild steel and the elastic strength over 30 per cent. higher, a greater reduction could have been made; and in future cases of the application of the high-tensile material, at least 20 per cent. reduction should be allowed. Plates under ¾-in. thick were generally made of high carbon steel while thicker plates were made of high silicon steel, as thick carbon steel proved slightly defective in the elastic limit. As the modulus of

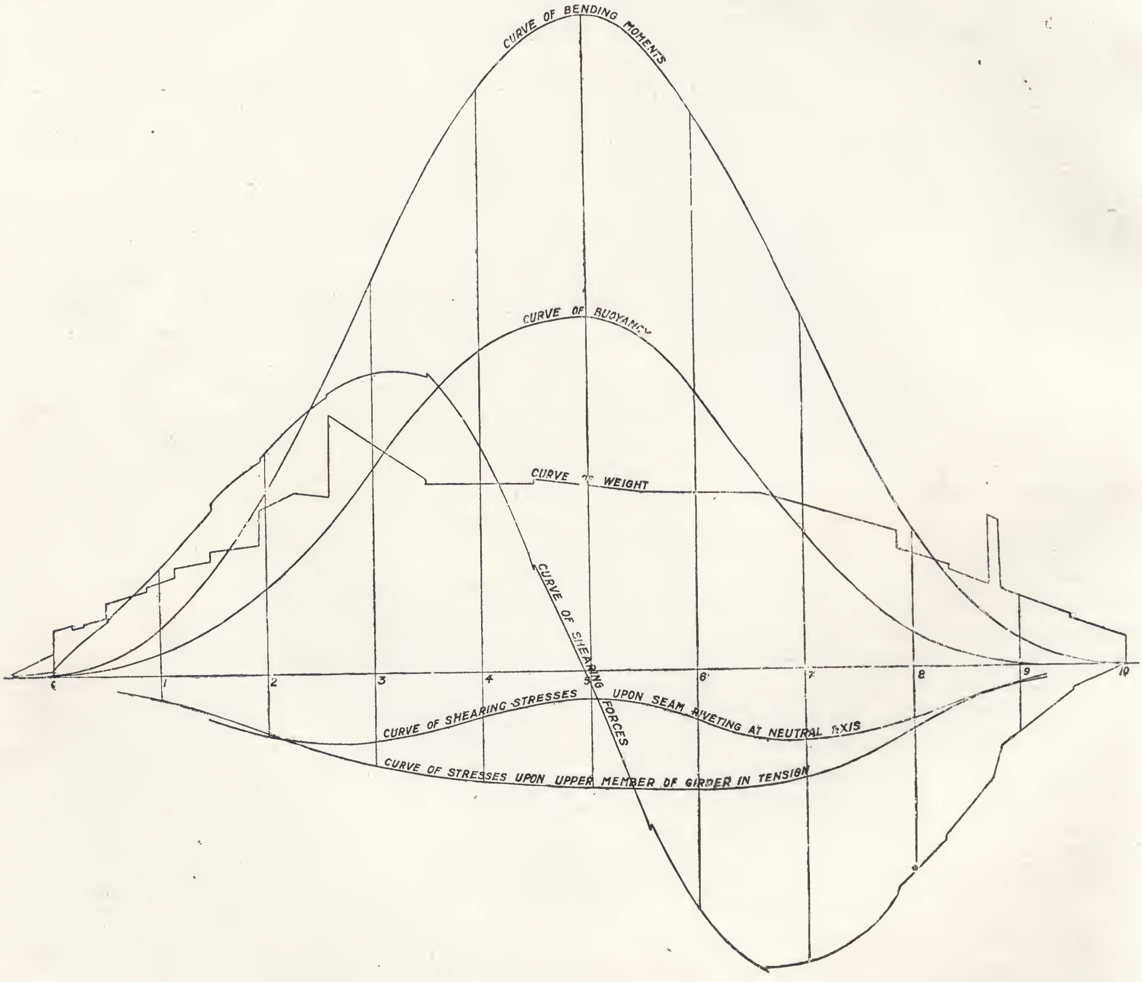


Fig. 3.—Stress Diagram.

* *The Shipbuilder*, Volume II., No. 5.

elasticity of the mild and high-tensile steel was shown to have the same value, no doubt exists upon the question of the two materials acting together and forming a homogeneous structure.

It is the usual practice in shipbuilding to maintain the midship scantlings of certain parts for half the length of the ship, or even for five-eighths or three-fourths of the length. This is a rough and ready method, which has no other merit than its simplicity to commend it. In the case of the *Mauretania*, it was decided to make a more logical distribution of the material in the hull, and to regulate the scantlings in the different sections by the work to be done. It seems rational enough to admit that the usual standard stress diagrams give the maximum bending moment occurring amidships, but this is not the case for the other sections. Stress diagrams, therefore, were got out for ten different positions of the standard wave crests in relation to the ship. maximum bending moment at the section by its modulus of resistance. This curve shows the stresses to be maximum amidships, decreasing regularly towards the ends owing to the tapering down of the scantlings having been done in a gradual and logical manner. It was, for instance, found possible to reduce the top scantlings more rapidly than the bottom ones. The alterations in the form of the sections, tending to a "V"-shape at the ends, raised the height of the neutral axis above the base line, and, if the usual rule-of-thumb methods had been adhered to, would have resulted in the bottom member, as compared with the top member, being subjected to greater stresses towards the ends. It was also found that, owing to less sheer, the midship scantlings should be maintained for a greater distance aft than forward.

At first it looks as if a further reduction of scantlings could have been made towards the end so as to obtain a more uniform maximum

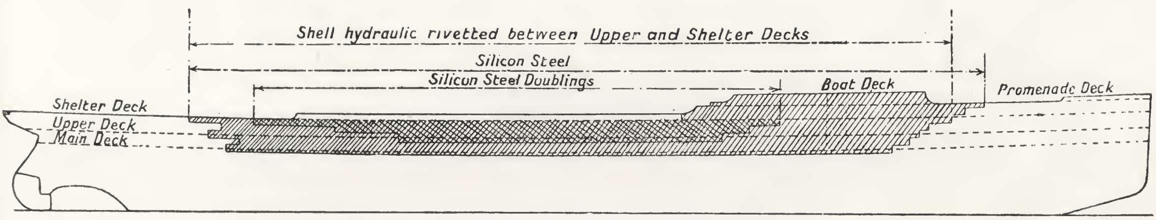


Fig 4.—Profile showing extent of High-Tensile Steel and Hydraulic Riveting of Topsides.

Fig. 5 shows the ten curves of bending moment corresponding to these positions.

The curves with the wave crest at No. 5 and No. 10 sections show respectively the bending moments for the ship on the crest and in the hollow of a wave and are the standard stress diagrams. It will be seen that the curve with wave crest amidships gives practically the maximum hogging moment occurring at any section for any position of wave crest, only one curve falling slightly outside it. With regard to the sagging moment, however, the curve with the wave hollow amidships is distinctly inside one of the other curves for a certain distance aft of amidships. This is principally due to the great buoyancy of the upper portion of the ship's form right aft which becomes immersed in the wave crest.

On the diagram Fig. 3 a curve is given showing the maximum stresses occurring at any section. This is obtained by dividing the stress fore and aft, and possibly to some extent this may be so. There are, however, two important factors to take into account. Firstly, the thickness of the plating cannot be reduced at the ends below a certain reasonable limit, and, secondly, in the above diagrams the ship's upright position only has been considered. If the vessel is inclined 30 degrees to the vertical the top and bottom members of the girder are then formed, not by the top deck and bottom plating, but by the material round about the gunwale bar and the bilges. The modulus of resistance decreases and the actual stresses increase in a corresponding degree. This decrease in the values of the modulus of resistance is more important as the width of the ship gets less, the percentage of reduction from upright values at the end sections being nearly twice that found amidships.

The effect of the shearing stresses has also been considered. About midships, where the

bending moments are maximum, the shearing forces are comparatively small and may be neglected, but this remark does not apply to other places. For instance, at about one-fourth of the ship's length from amidships the stress in the shell plating near the tankside, due to the bending moment alone, worked out at 4·30 tons to the square inch, and this increased to 5·80 tons when the shearing stresses were taken into account. By thus checking all the critical points, it was found that, with the scantlings adopted, in no portion of the structure was there any danger of the limit of safety being exceeded.

The shearing stresses in the seam riveting are maximum near the neutral axis, a curve showing their value at different sections being given in Fig. 3. The maximum shearing stress occurs at about one-fourth of the ship's length from amidships, and has a value of 6·30 tons per square inch of material in the cross section of the rivets, the seams being treble riveted. Similar calculations made for other vessels with double riveted seams gave in one case 7·35 and in another 8·10 tons per square inch. No trouble has, so far as is known, been experienced with the riveting of these vessels; but as other ships of similar dimensions have been reported to be unsatisfactory in this respect, the figure last quoted must be considered too near the dangerous limit. The maximum stresses in the shell plating worked out in the three cases under consideration at 3·84, 3·58 and 4·12 tons per square inch respectively.

In Fig. 6 are given the equivalent girders of a number of well-known Atlantic liners, *viz.*, the *Ivernia*, *Campania*, *Deutschland*, *Kaiser Wilhelm II.*, *Oceanic* and *Mauretania*, and

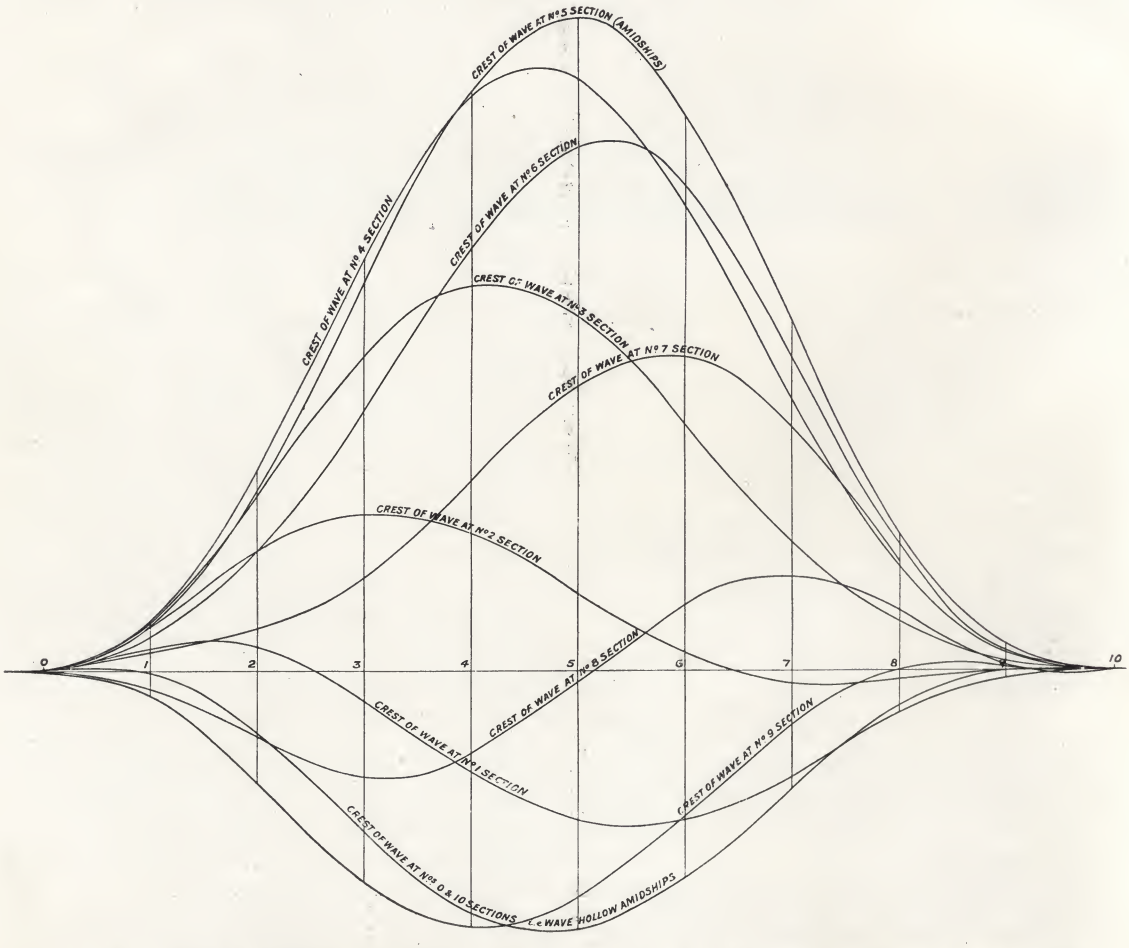
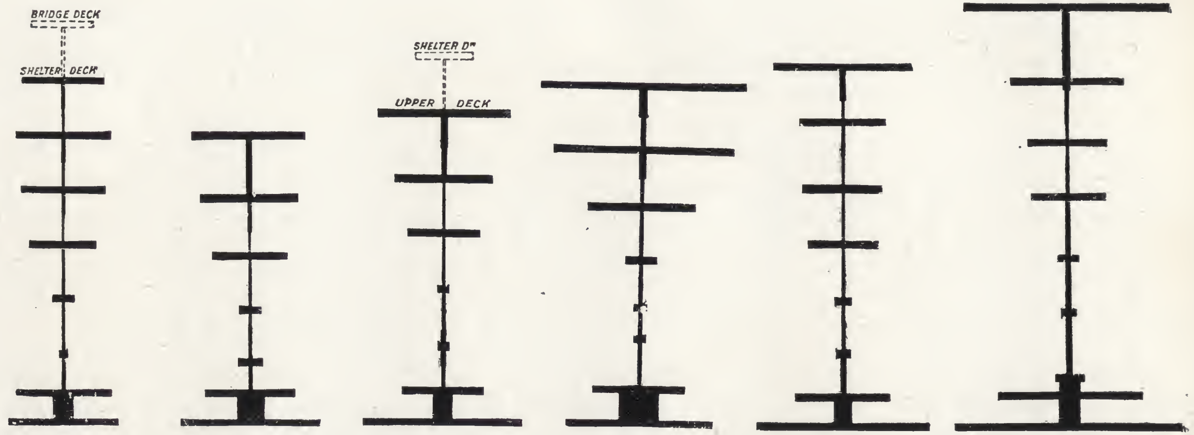


Fig. 5.—Curves of Bending Moments with Wave Crest at different positions in the Length.



NAME.	"IVERNIA."		"CAMPANIA."	"DEUTSCHLAND."		"OCEANIC."	"KAISER WILHELM II."	"MAURETANIA."	
Dimensions.	580′ × 64′ 6″ × 49′ 6″		600′ × 65′ 3″ × 41′ 6″	662′ 9″ × 67′ 3″ × 44′ to U.D.		685′ × 68′ 4″ × 49′ 0″	678′ × 72′ × 44′ 2″	760′ × 88′ 0″ × 60′ 6″	
	To Shelter Deck.	To Bridge Deck.		To Upper Deck.	To Shelter Deck.			Mild Steel basis.	H.T. Steel actual.
Depth of equivalent Girder in feet	50·68	59·14	43·16	45·42	53·25	50·91	53·64	62·06	62·06
Area of Section in square inches	4241	4641	4146	4330	4696	5814	4994	7957	7709
Moment of Inertia in sq. ins. × ft.^{2}	1362840	1809220	1037910	1246790	1601970	2135150	2003640	4253670	4062210
Minimum Modulus of Resistance in sq. in. × ft.	48450	53880	43360	48930	52010	79880	69720	131450	122300
Draught	32′ 0″	...	29′ 0″	28′ 6½″	...	32′ 6″	29′ 6½″	33′ 6″	...
Displacement	24790	...	21000	22850	...	30100	26080	37960	...
Block Co-efficient	·725	...	·647	·64	...	·69	·635	·600	...
Bending Moment as calculated in feet-tons	481000	...	...	...	...	...	...	973000	...
Co-efficient $C = \frac{\text{Displacement} \times \text{Length}}{\text{Bending Moment}}$	29·88	...	...	...	...	...	...	29·65	...
Stress with calculated Bending Moment in tons per sq. in.	9·93	8·93	...	...	...	..	...	7·40	7·95
Bending Moment assumed $\frac{D \times L}{29·25}$	...	...	430000	517000	...	704000	604000	...	...
Stress with assumed Bending Moment in tons per sq. in.	...	...	9·94	10·58	9·96	8·83	8·66	...	...

NOTE.—MODULI OF RESISTANCE.—Only longitudinal steel material has been taken into account, all wood decks being neglected. No deduction has been made for deck openings or rivet holes. The value of the actual modulus of resistance in way of hatchways and deducting rivet holes is generally about 70 per cent. of the values given in the tables.

BENDING MOMENTS.—The bending moments have been calculated upon the assumption that the vessel is placed upon the crest of a wave having a length equal to her own length and a height equal to 1/20th of the length. The ship is supposed to be nearing the port of arrival with bunkers nearly empty, having been loaded at departure to the draught given in the table. In the case of actual bending moment calculations made at Wallsend, the actual value of the co-efficient 'C' was found to be 29·25, and this value has been adopted for estimating the bending moments in the cases where their actual values were not available.

Fig. 6.—Equivalent Girders of large Atlantic Steamers.

the principal particulars are given underneath the girders. In the calculations the sections have been taken amidships right across the ship, without any allowance being made for hatchways, deck openings and rivet holes. In calculating the moment of inertia and modulus of resistance, account has only been taken of the continuous longitudinal steel material, including the intercostals in the double bottom minus a certain proportion to allow for manholes. No wood material has been included. The bending moments have been taken as a function of the displacement multiplied by the length. Calculations made for different ships of which all particulars are known, and for several designs of ships 750 and 760 feet long and of different block co-efficients, showed that the maximum bending moment M was in all cases obtained, with good approximation, by dividing the product D × L by the constant factor 29·25, D being the displacement of the ship loaded to the draught given, and L the length between perpendiculars. The maximum bending moment M corresponds to the standard condition, the ship being assumed on the crest of a wave of length equal to her own length and height equal to one-twentieth of the length. As the other ships in the table do not differ much with regard to the general distribution of weights from those for which calculations were made, the same formula

$$M = \frac{D \times L}{29{\cdot}25}$$

is taken to apply. The figures given for the stresses do not, of course, represent the maximum stresses under standard conditions at the weakest point. Allowance should be made for deck openings and rivet holes, and for the amount of compensation provided at these points. The correction to be made, however, was found to be fairly constant in ships built in accordance with the usual practice, so that the relative value of the figures is not altered to any material extent. These figures show that in the case of the *Mauretania* strength and rigidity have not been sacrificed to obtain the advantage of speed, the maximum stress being appreciably less than in all the other ships mentioned in the table.

A comparison between the section of the *Deutschland* and the *Kaiser Wilhelm II.* is of interest. In the first ship the main structure may be said to stop at the upper deck, the shell above this deck and the continuous shelter or lower promenade deck being of much lighter scantlings. This light superstructure is marked on the equivalent girder by dotted lines, and in the table are given the figures corresponding to the two girders, *i.e.*, with and without the material in this superstructure. By including the latter, the depth of the equivalent girder, its moment of inertia and modulus of resistance are increased and the maximum stress is correspondingly decreased, so that apparently an advantage in strength is gained. This may be true so far as the hogging or tensile stresses are concerned provided butts and longitudinal connections are properly designed; but under sagging or compressive stresses on the top member, the thin plating may not stand up to its work and may buckle between the beams, at once throwing the work on to the more rigid portions round the gunwale and those parts of the deck which are stiffened by fore and aft hatch or deck house coamings. The material in those places may thus be strained beyond its elastic limit, and finally show signs of weakness if it does not actually break down. This has actually happened with the top deck of the *Deutschland* and other large steamers built on the same principle. Building superstructures of light scantlings over the main structure is rational enough when they are in short lengths; but if continuous they should only be adopted in the case of vessels of smaller dimensions, where the longitudinal stresses are of less importance and do not influence the scantlings to the same extent as in larger ships.

In the *Kaiser Wilhelm II.* the shelter or lower promenade deck is 22·5lbs. against 12lbs. in the *Deutschland*, the shell plating 37lbs. against 19lbs., and the stringer and shell doublings have been transferred to the top deck, giving a more efficient disposition of material. The result is that the relative stresses, calculated as explained above, are decreased from 9·96 to 8·66 tons to the square inch, while the latter stress comes upon much thicker material.

There is no doubt that in many large shelter-deck ships a saving in material could be effected by further stiffening the top structure and reducing the scantlings below, that is, the deck plating of the upper and main decks and the side plating above that level; but this may clash with ideas prevailing in certain quarters, where it is held that for ships of the same class the thickness of plating must be regulated by

the dimensions of the ship rather than by the more rational consideration of the stresses involved.

Before leaving this subject, it may be well to point out that the strengthening of the superstructure makes it more difficult to fit large gangway doors in the sides between the upper and shelter decks, the question of compensation in way of these openings becoming a very serious one. In the case of the *Mauretania*, the doors were, therefore, fitted lower down between the main and upper decks. Another consequence is that, whereas the stresses on the top member are decreased, those on the bottom and bilge plating, forming the bottom member, may be increased; and a point may be reached where the trouble would be transferred from the top structure to the bottom plating if proper precautions were not taken. This stage appears to have been reached in

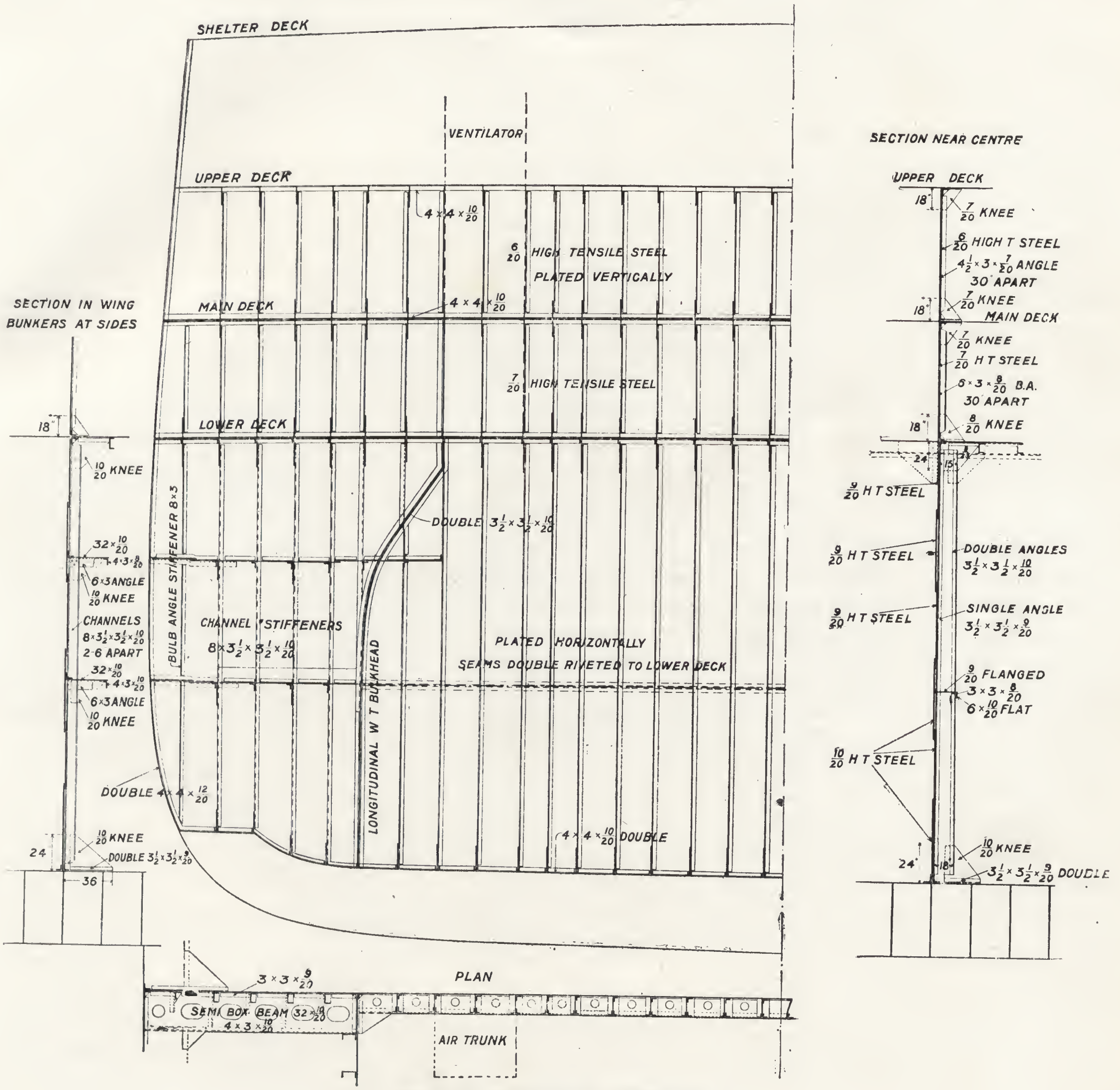


Fig. 7.—Bulkhead Stiffening.

large oil-tank vessels, where the absence of a double bottom causes greater stresses upon bottom plating than in other ships of the same dimensions. No doubt if this subject were more carefully considered by shipbuilders, improvements in the design of the structure of large ships could be obtained.

The transverse strength of the *Mauretania*, as can be seen on the midship section already referrred to, is amply provided for. The double bottom extends well up the bilges, and the tank side connection of web frames and frames is made very rigid by continuous face angles or channels connecting the knees to the tank top plating. The web frames, 36 inches deep, with double face angles and double angle connections to the shell, are spaced 10ft. 8in. apart throughout the greater portion of the ship's length, being closer spaced in the engine rooms. Numerous transverse bulkheads, as shown in the profile, extend to the upper deck, while above this deck partial bulkheads, and ventilating trunks specially stiffened for the purpose, contribute to the transverse rigidity of the upper structure.

On Fig. 7 are shown the scantlings of the transverse bulkheads. These are in excess of the Bulkhead Committee's recommendations taking the upper deck as the bulkhead deck, although detailed calculations showed that in no case, with any two adjoining compartments bilged, would the water level come within several feet of the margin of safety line. Even should the longitudinal bulkhead in one of the boiler or engine rooms be pierced or a watertight door fail to act, the factor of safety would still be greater than in most existing ships. This result has been obtained, without excessive weight of material, by proportioning the scantlings of each bulkhead to the actual water pressure which might be brought upon it. Fig. 7 does not represent an actual bulkhead in the ship, as passages for the men on board and for steam pipes, etc., had to be provided; but in all cases the same standard of strength has been adhered to for the longitudinal as well as the transverse bulkheads.

* * * *

Docking Investigations.

In connection with the transverse strength of the ship, the question was raised as to the capability of the bottom to resist the pressure brought against it when in dry dock; but no doubt can be felt as to the strength being ample when the scantlings in this part of the structure are compared with those found in the case of heavy ironclads. Approximate calculations were made, which confirmed this view. As it was considered, however, that a certain deflection might occur in the double bottom between the bulkheads, causing the floors under them and in their immediate vicinity to bear more heavily on the blocks, double bars were fitted to the floors and intercostals at these places.

A most interesting problem was presented with regard to the maximum pressure the ship was likely to exert on the blocks in dry dock, especially on account of the heavy overhanging portions at each end, where the keel rises from the straight leaving a long portion of the structure without any direct supports underneath—at any rate until the dock is pumped dry and shores have been placed in position. Some investigations were made in connection with this problem, and the diagrams on Fig. 8 show some of the results.

In order to simplify the problem the weight is assumed to be disposed symmetrically with regard to the midship section. The crooked shape of the weight curve as used for the strength calculations is replaced by a more regular form, the weight per foot run being assumed to be uniform for a certain length amidships and then to decrease in a straight line towards the ends. The lines are drawn so that the total area remains the same, as also the fore and aft positions of the centre of gravity for the half-body of the ship. The other half being taken to be symmetrical, calculations were only required for the after body. The keel blocks are to be spaced uniformly under the straight portion of the keel, and are assumed to be perfectly elastic within the limits of the loads coming upon them; the compression being at the rate of ½in. for a load of 40 tons per foot run of keel, or 100 tons on each keel block if the spacing is 2ft. 6in. Referring to Fig. 8, curve 1 represents the distribution of weight, curve 2 the moments of inertia of the sections, and curve 3 shows the compression of the blocks when the overhanging portion is neglected, *i.e.*, is supposed to be non-existent. This curve has been obtained by methods of trial and error in the following way. A curve of deflection is assumed; and the total weight being known the reaction of the blocks at each portion of the keel is determined, and a curve of reaction corresponding to the curve of buoyancy in the stress diagrams drawn. Hence, by graphic

integration, the curves of loads of shearing forces and of bending moments can be obtained as in the strength calculations. With the aid of curve 2 giving the moments of inertia at the different sections, the curve of slopes of the neutral axis, and finally the resulting curve of deflection, can be obtained. The latter curve must be the same as the assumed curve. If not, the assumed curve must be more or less modified and the same process gone through into account, and has been obtained in a similar manner by methods of trial and error. The pressure on the end block is considerably increased, while amidships the pressure is less than in curve 3. The end blocks act as a fulcrum, over which the overhang balances part of the midship weight, the result in the present case being that the pressure over the blocks is fairly uniform and not excessive at the ends. In other words, the effect of the

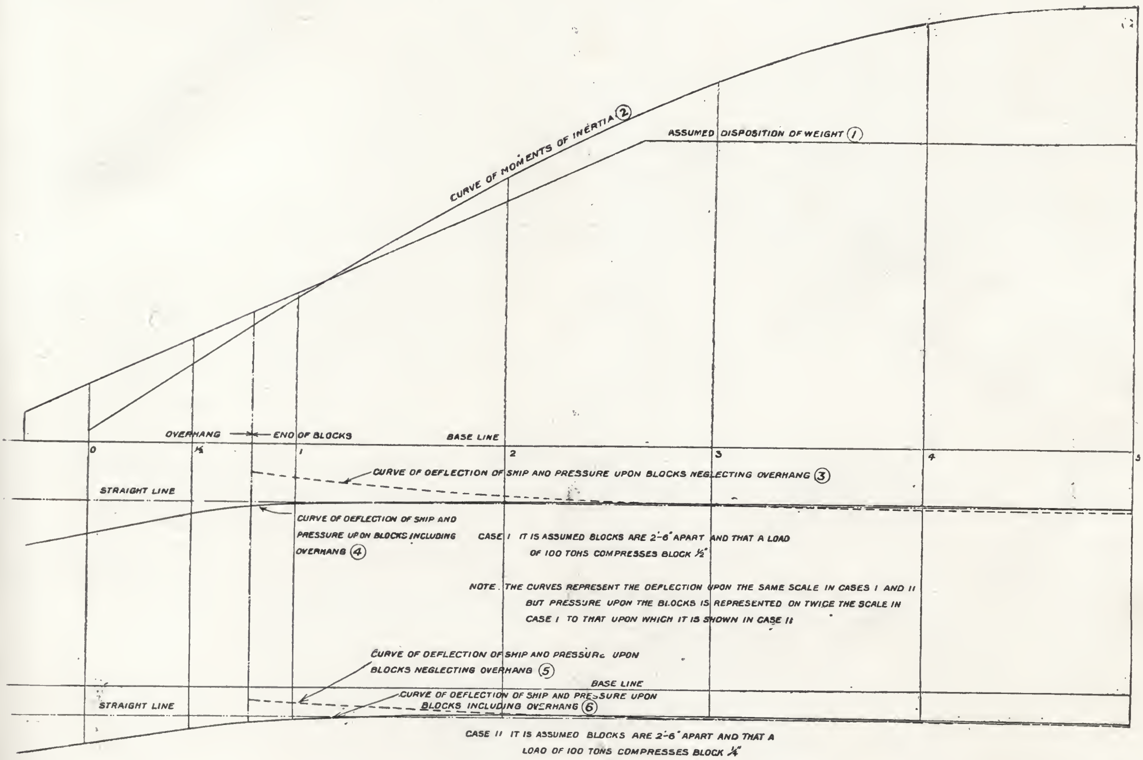


Fig. 8.—Docking Pressures.

until the two curves coincide. Curve 3 shows that the assumption sometimes made that the ship could be considered as perfectly rigid and its weight spread uniformly over the blocks was entirely erroneous in the case under consideration. A much closer approximation is obtained by supposing the ship perfectly flexible, *i.e.*, resting on the blocks like a chain, each block supporting the weight over it.

Curve 4 shows the deflection and also the load on the blocks when the overhang is taken overhang is compensated by the smaller weight per foot run of the structure at the ends.

Curves 5 and 6 are the curves corresponding to 3 and 4, but with harder blocks, the compression being only taken at $\frac{1}{4}$-inch with a load of 40 tons per foot run of keel. The pressure on the end block is increased, as might have been expected; showing that, when docking heavy ships with considerable overhang, the more elastic wood keel blocks (in accordance with the Royal Dockyard practice) are preferable

to cast metal ones. When the latter are used, a hard wood timber block with soft wood cap pieces should be placed between the iron block and the keel of the ship, so that the soft wood may yield wherever the pressure is excessive and distribute the weight of the ship more uniformly. Soft wood only would not be satisfactory, as under a heavy load it would be crushed and compressed to a solid mass without elasticity. It was found by experiments made for the purpose that hard wood, and especially elm, maintains its elasticity under very heavy loads.

* * * *

Stability and Bilging Investigations.

To gain steadiness at sea, it is usual to design passenger steamers with fairly small metacentric heights; but there are two objections to this course. Firstly, such vessels when exposed to a beam wind often take an unpleasant list on account of their large exposed superstructure; and, secondly, if the ship gets damaged the loose water in the compartment in communication with the sea may reduce the stability to a dangerous extent. Neither of these two defects need be feared in the *Mauretania,* as the metacentric height is sufficient under all working conditions to prevent the ship heeling over under the action of a beam wind, while the great inertia due to her enormous weight and dimensions gives her a period of rolling equal to that of the steadiest liners afloat. The steadiness of the ship at sea is further improved by the large bilge keels, over 200 feet long and 3 feet deep, which, together with the propeller bossings, will increase the resistance to rolling and keep the angle of roll within very reasonable limits. The rolling period at sea was actually found to be over 20 seconds for a double roll.

The stability when damaged has also been carefully investigated; and although the vessel may take an unpleasant list should two of the wing compartments be flooded when the bunkers are empty, she will always have a good positive metacentric height with a long range of stability. It will be an easy matter to right her again by filling some of the double bottom compartments on the opposite side, the double bottom having for this purpose a central watertight division fitted for nearly the full length of the ship.

Model Experiments.

By E. W. DeRusett, M.Inst.C.E., M.I.N.A., and M. Wurl, Dipl. Ing.

THERE are two specially important functions in connection with shipbuilding which the public and technical press delight to dwell upon—the launch and the trial trip—when the skill of masters and workmen is more or less deservedly lauded; but how seldom is a note of praise accorded to the unseen work upon which the whole of the fabric is based. The object of this article is to draw the attention of readers of *The Shipbuilder* to some of the root matters in connection with the initial work connected with the *Mauretania*.

It is perhaps hardly necessary to point out that the dimensions and form of model best suited for the attainment of the object in view had to be determined, the power required for its propulsion fixed, and the general design decided, besides the many initial technical considerations which affect structure and cost, and which lay the foundation of success or failure, whether viewed from a mechanical or commercial standpoint. To bring our subject within readable limits, the work in connection with the model and power of the vessel will alone be specially dealt with.

At the outset it should be borne in mind that a successful model must, of course, make for speed, economy, and steadiness, in both smooth and troubled waters; and these considerations are of the utmost importance, and especially so in the case of an "express" passenger steamer.

With an ordinary vessel, before the model and design can be judiciously determined, the conditions of working—such as the trade and the waters in which the ship will be employed, and the average weather likely to be encountered—have to be taken into consideration and provided for. This is comparatively an easy task when the contemplated vessel is within the reasonable limits of known practice; but where the demands are extreme as regards speed in relation to length, cost and economy of fuel, or where the dimensions and speed are each much beyond the bounds of experience, then the problem calls for more than ordinary investigation to ensure its successful fulfilment. Consequently, in the initial stages of the design of the *Mauretania*, the solution was sought for, not only mathematically, but experimentally with models *towed* in a tank, followed by experiments made with a *self-propelled* model, 47ft. 6in. long, which was exhaustively tried in an enclosed dock.

At the early stage the resistance of naked models of various forms and dimensions, *i.e.*, those without bossing or rudder, was arrived at

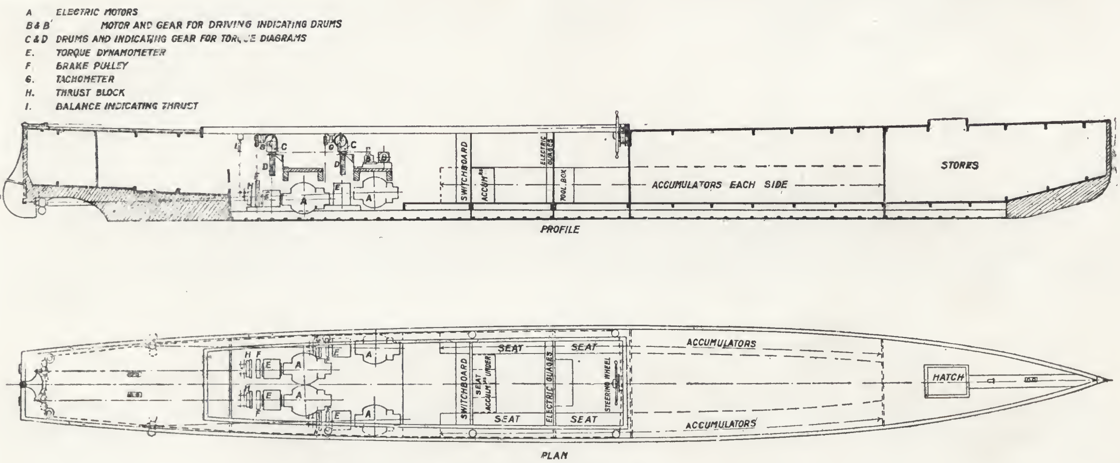


Fig. 9.—Electric Launch.

by a series of valuable towing experiments made in the Admiralty tank at Haslar under smooth-water conditions. These models varied much in dimensions, fineness and form, representing, among others, vessels of (1) 760ft. long by 80ft. wide, with a displacement of 34,000 tons and a block co-efficient of ·644, (2) 725ft. by 80ft., with 32,900 tons displacement and a block co-efficient of ·631, and (3) 760ft. by 78ft., with a displacement of 33,500 tons and a block co-efficient of ·648. It will be noted by these figures that, although the conditions to be fulfilled were the same in each instance, the dimensions and fineness varied a good deal. The effective power at corresponding speeds also differed to the extent of 6 or 7 per cent., the margin for weight of machinery, boilers, equipment, cargo, passengers, mails, baggage and coal was necessarily very limited. It was also essential to determine whether the vessel was to be propelled by three or four screws. This was a difficult problem in itself to solve, as at that time nothing was known of the efficiency of quadruple screws and comparatively little concerning triples, especially as to the effect on efficiency of water flowing from the advanced to the rear screws. The most suitable shape of bossing, the position of the propellers in relation to each other and to the vessel's hull, and other details affecting propulsive efficiency had also to be thrashed out.

As the magnitude of the venture was such

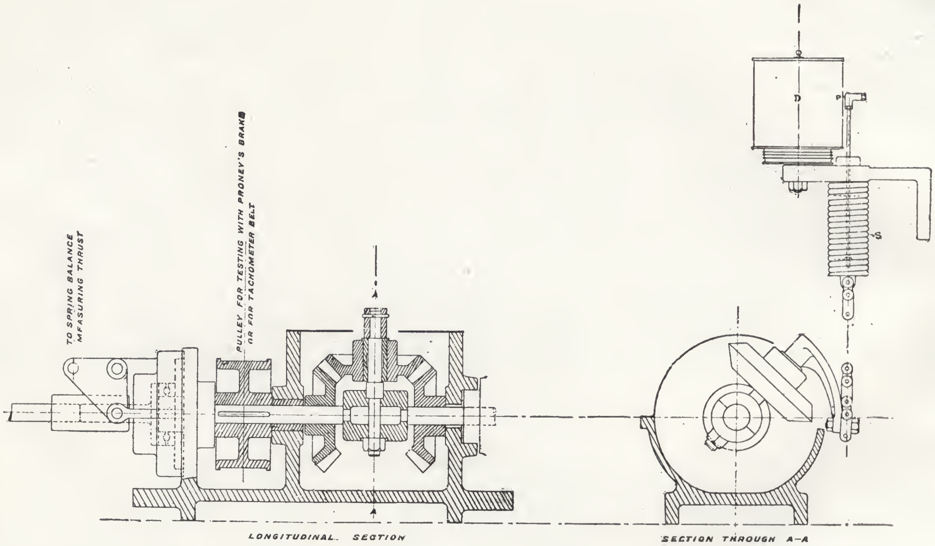


Fig. 10.—Torque Dynamometer and Thrust Indicator.

and the Admiralty constant varied as much as 8 per cent., although each model was designed by an experienced naval architect, thus showing the need of model experiments to test the results of mathematical processes. Based upon further tank experiments and developments in design, the present dimensions were determined upon, *viz.*, 760ft. long between perpendiculars and 790ft. over all, by 88ft. wide, with the fineness and form best adapted to ensure economical steaming and stability at sea.

The effective or towing horse-power having been ascertained, the next difficulty was to arrive at the propeller efficiency and indicated horse-power—questions of much importance, since the power was so immense, and as to allow no risks to be run, it was felt that, although the tank experiments by towing naked models had been made with the greatest care, it was desirable to go further, and to experiment on these very important details with a larger model than could be tested in a tank. Consequently the Chairman of Swan, Hunter, & Wigham Richardson decided to have such experiments carried out in a launch to be self-propelled by engines and truly modelled propellers, of such dimensions that the power and efficiency could be translated into the full size with the minimum risk of error. The model was to be large enough to afford ample space for operators and the necessary recording instruments; and it was

also deemed advisable that provision should be made in its construction in order that the best form of shell bossing and run, and the most suitable position for propellers, could be arrived at for propelling efficiency and rapid manœuvring, especially as the vessel was to be adapted for use as an auxiliary cruiser in His Majesty's Navy. This model launch was designed in October, 1903, to one-sixteenth of the dimensions of the full-sized vessel.

A suitable place for the experiments was found in the Northumberland Dock on the North side of the River Tyne, where the depth of water exceeds 24 feet, and the width of the water passage is generally 100 feet, so that the results of the speed trials with the launch were not appreciably affected by narrowness in any direction. Currents were, of course, absent, and this simplified the observations and was conducive to accuracy. The distance available for the speed trials is about a quarter of a mile, after allowing ample space for regaining speed after turning.

The experimental launch, which is illustrated in Fig. 9, was built of two thicknesses of yellow pine, with solid deadwood forward and aft and solid portable bossing, all so contrived that the form of each could be altered as required. The craft was electrically propelled by means of an accumulator battery strong enough to keep up full speed for about 3 hours. The machinery consisted of 4 electric motors with a speed regulation between 150 and 950 revolutions per minute. Each motor was arranged to drive a separate propeller shaft, coupled by means of a self-recording torque dynamometer (see Fig. 10), specially designed for this purpose. The principle of this instrument is an old one, and will be readily understood from Fig. 11. The driving wheel A exerts a force, P, downwards upon the intermediate wheel C. The reaction from the resisting wheel is also P, and acts in the same direction upon wheel C revolving freely upon its axis, which is allowed to swing through an arc and is supported at the swinging end by a spring, S. The general design is such (Fig. 10) that the extension of this spring is proportional to the force P, and consequently proportional to the turning moment on the shaft, which is recorded by a pencil, p, upon the indicator drum D. This drum, with the indicator paper on its outside, is made to revolve slowly during each test by means of a small motor and gear (Fig. 9). During the intervals the drum is stopped, so that the pencil is only moving up and down upon the paper, thus marking the beginning and the end of each test. A representative torque diagram is shown on Fig. 12. It contains 14 tests (runs on a measured distance) indicated by numbers, while a, b, c and d represent tests to ascertain the zero line for the diagram, and to eliminate errors due to friction, etc. The number of the diagrams of this kind obtained during the various experiments amounted to about 400, each of them containing about 12 tests. To be able to calculate the shaft horse-power from these diagrams, the torque dynamometers were tested with Prony's brake upon a pulley provided for this purpose (Fig. 10). Frequent tests with the brake showed that the scale in which the turning moment was recorded on the diagrams remained constant, a proof that the instruments were reliable for measuring turning moments accurately.

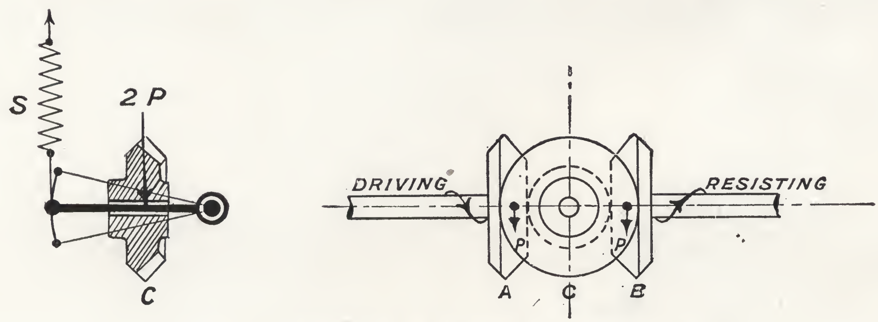


Fig. 11.—Principle of Torque Dynamometer.

The arrangement for measuring the thrust is also indicated in Fig. 10. The ball thrust bearing was so supported that its load was indicated by a spring balance. The number of revolutions of the shafts was ascertained on the trials by electric counters and by tachometers (see Fig. 9). The speed of the launch was

measured in the usual way, by running over a measured distance and taking the time by a stop watch. The velocity of the wind was measured by an anemometer during each run, and the mean direction of the wind relative to the course of the vessel was noted.

These wind measurements were found to be absolutely necessary to ensure the accuracy of the speed results, as, after a number of tests, it became evident that enormous errors could be made by simply taking the mean of two runs in opposite directions, *i.e.*, with and against the wind. Comparative tests, for instance, showed that the mean power required with a wind of 18 knots' velocity was over 20 per cent. higher than in calm weather for the same speed. A large number of observations were required to establish a method for calculating and eliminating the effect of the wind on each test, in order to render an accurate comparison of the results possible.

At the beginning of the experiments, considerable difficulties were also experienced through the foulness of the launch's bottom, which increased rapidly and irregularly after exposure for some time. Cleaning with the brush proved useless, as it was found that the horse-power could not be brought down to its original amount, and that after applying the brush the fouling became all the more irregular and its amount untraceable. After several weeks of experimenting, however, sufficient information had been gained to deal successfully with these difficulties, and either to avoid fouling or eliminate its effect when necessary.

Although the E.H.P. for the ship had been ascertained by tank experiments, as already mentioned, it was deemed desirable to verify these results, and it was therefore necessary to arrive at the resistance of the model launch by towing. A rope about 1,500 feet long was used for this purpose, connected by one end to a dynamometer on shore. By means of the electric motors and special gear (Fig. 13), the launch was hauled along this rope at various speeds while the pull on the dynamometer was recorded. In applying the results to the full-sized ship by means of the law of comparison, a satisfactory agreement was obtained with the previous tank experiments. Even if the results had not agreed so closely, however, the value of the electric launch experiments, when applying the results comparatively for studying the effects of modifications in the design, would scarcely have been diminished.

The experiments extended over nearly two years, and the information obtained is so

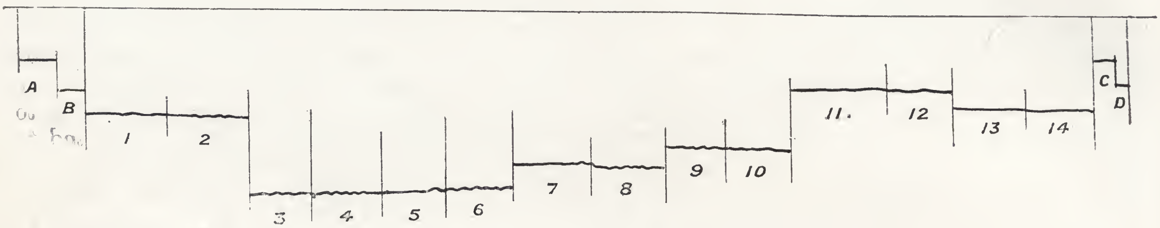


Fig. 12. Torque Diagram.

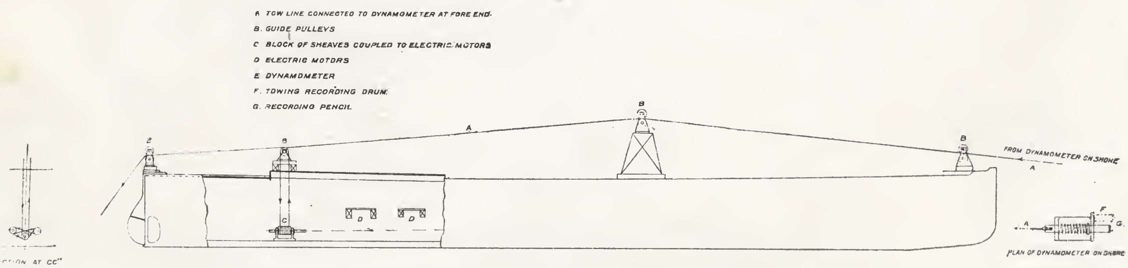


Fig. 13.—Towing Arrangement.

voluminous that the various questions and problems experimented on can only be briefly enumerated here :—

(1) Effect of aperture in deadwood between inside propellers.

(2) Effect of cutting away the deadwood as adopted for the full-sized ship.

(3) Effect of wind in various directions, and at different velocities, upon speed, power, etc. The deck erections of the ship were approximated in shape by a superstructure on the launch, as shown on Fig. 14, and the total wind resistance ascertained in the manner mentioned above. The results were applied to the full-sized ship by the law of comparison. To give an idea of the wind forces, it may be mentioned that the *Mauretania* when travelling at 25 knots per hour is expected to require about 12 per cent. more power against a wind of 25 knots than required in calm weather. With a following wind of 25 knots, the power will be about 4 per cent. less than in calm weather.

(4) Effect of fore and aft position of outside propellers, and of their distance from the hull, upon the propulsive efficiency. The importance of these trials will be seen from the fact that the variation in power for the same speeds amounted to as much as 5,000 I.H.P.

(5) Comparative efficiencies of the proposed four-screw arrangement, and of the usual twin-screw arrangement with large propellers as used with reciprocating engines. These experiments showed that the efficiency in both systems is about equal.

(6) Best direction of turning (inside or outside) for screws, with regard to propulsive efficiency.

(7) Effect of dragging screws if part of the machinery be disabled.

(8) Comparative distances and times of stopping for a twin-screw steamer and the turbine vessel.

(9) Steering and turning by rudder and by screws. It may be noted that these experiments proved the advantage which could be gained, and actually has been gained, by cutting away the deadwood and thereby reducing by 25 per cent. the space required for turning the ship. The experiments also showed that the adopted arrangement is superior to the ordinary twin-screw arrangement in regard to turning by rudder.

(10) Astern speeds obtainable with the proposed arrangement and the proposed percentage of astern power by rudder.

(11) Experiments to find the most suitable propellers with regard to high number of revolutions and high efficiency. Twelve sets of propellers of different proportions were tested for this purpose, necessitating over 500 speed trials. Nearly all the model propellers were made by the Wallsend Slipway & Engineering Co., and corresponded minutely in diameter, pitch, surface, blade

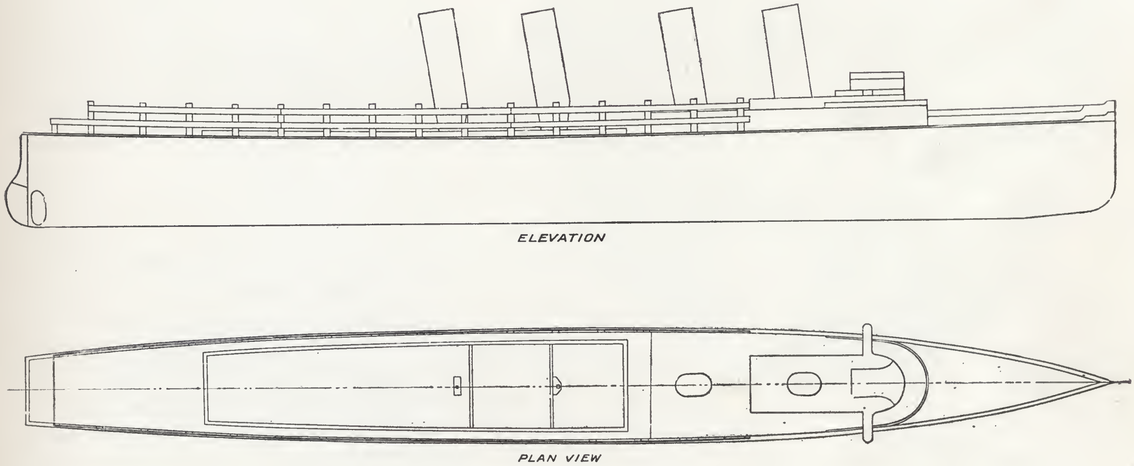


Fig. 14.—Erections on Launch to test effect of Wind upon Speed, &c.

thickness, shape and diameter of boss and cone with the various propellers proposed for the full-sized ship. The experiments have shown how much there is still to learn concerning screw propellers, as the efficiencies varied as much as 12 per cent. between propellers proposed as most suitable by various authorities. The final achievement of these numerous propeller experiments was a considerable increase in the number of revolutions, whereby it has been possible to make the turbines more economical; and, contrary to the general practice in turbine steamers, the propellers finally selected for the ship are nearly as efficient as the slow-running propellers of an ordinary twin-screw vessel of the same proportions.

(12) Effect of draught and trim upon speed, power, etc.

(13) Measurement of wave profile. The illustration in Fig. 15 shows the comparatively small height of bow and stern waves.

(14) Measurements of the relative velocity of the water at different distances below the surface of the water, and at various distances from the hull, including the speed of the wake at different positions longitudinally.

(15) Trials to ascertain the amount of skin friction upon surfaces similar to those of the electric launch.

Altogether a large amount of most valuable data has been obtained regarding the intricate problems of ship resistance and propulsion, which will be of great assistance to the builders of the *Mauretania* when grappling with similar problems in the future.

After the completion of the experiments in connection with the *Mauretania*, the electric launch was employed on a series of systematic propeller experiments, made in the joint interests of Swan, Hunter, & Wigham Richardson, the Parsons Marine Steam Turbine Company, and the Wallsend Slipway & Engineering Co., and valuable information was obtained with regard to propellers of small pitch ratios. Still more recently, many further tests and trials have been made, principally in connection with the new system of combining reciprocating engines and steam turbines. At the present time, the launch may occasionally be seen running in the Northumberland Dock, engaged in the investigation of problems which have yet to be solved if scientific shipbuilding is to advance.

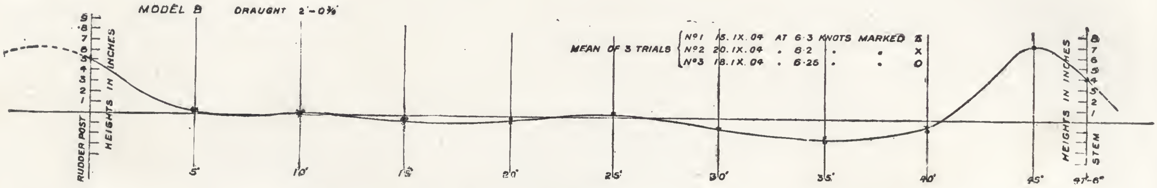


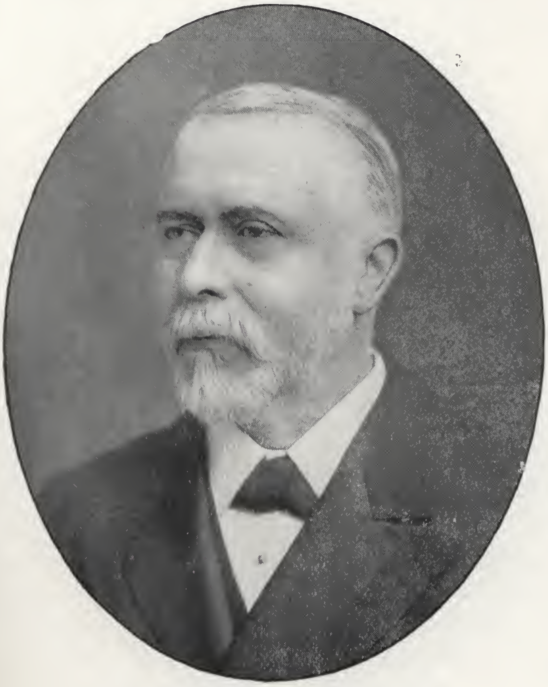
Fig. 15.—Wave Profile. (Heights exaggerated 5 times.)

The Shipbuilders.

NO shipbuilding company was more qualified to undertake the construction of so large a vessel than Messrs. Swan, Hunter, & Wigham Richardson, Ltd., and in placing the order for the *Mauretania* with this company the Cunard Company were dealing with shipbuilders whose capability they knew. Three large passenger vessels—the *Ultonia*, *Ivernia*, and *Carpathia*—had already been built for the Cunard Company at the famous Wallsend Shipyard, these vessels having given great satisfaction to their owners.

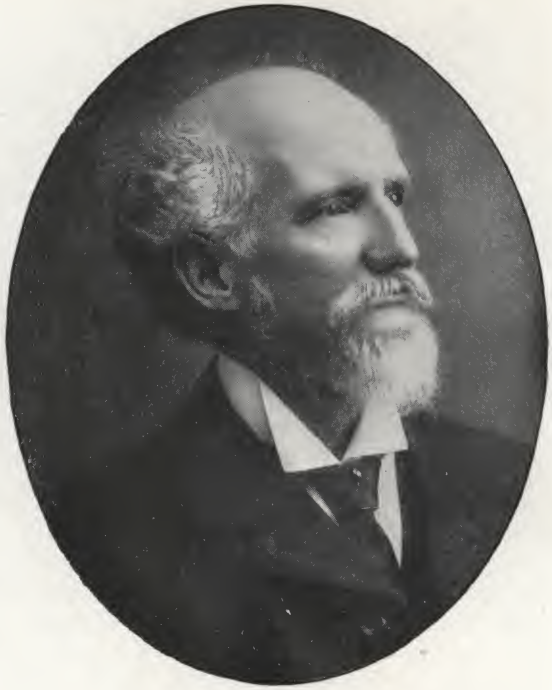
Mr. Hunter, the chairman of the shipbuilding company, has made a study of the Atlantic passenger trade, and has crossed the Atlantic many times. From the outset of the negotiations with the Cunard Company, he has kept in close touch with the design and construction of the *Mauretania*. The shipbuilding company had also the advantage of numbering among its directors Sir William H. White, K.C.B., formerly Director of Naval Construction of the Royal Navy. Sir William was nominated to represent Messrs. Swan, Hunter, & Wigham Richardson as a member of the committee appointed by the Cunard Company to consider the advisability of propelling the vessel by turbine machinery, and has acted as consulting naval architect to the shipbuilding company. Mr. Charles S. Swan, another director, has also been closely engaged in the construction of the vessel, and has given personal attention to details. Among the members of the shipbuilding staff who have been intimately connected with the construction are Mr. E. W. DeRusett, Mr. J. Meuwissen, Mr. M. Wurl and Mr. C. Stephenson. Mr. DeRusett is the naval architect at the Wallsend Shipyard, and has for many years been associated with the long list of successful vessels of almost every type which the Wallsend Yard has to its credit. Mr. Meuwissen had charge in particular of the calculations required

Mr. G. B. Hunter, D.Sc.



Sir William H. White, K.C.B.

Mr. C. S. Swan.



Mr. E. W. DeRusett.

Mr. Christopher Stephenson.

Mr. J. Meuwissen.

OFFICIALS OF THE CUNARD STEAMSHIP COMPANY.

Mr. A. D. Mearns.
(General Manager.)

Mr. James Bain.
(General Superintendent.)

Mr. L. Peskett.
(Naval Architect.)

Mr. G. Thompson.
(Engineering Superintendent.)

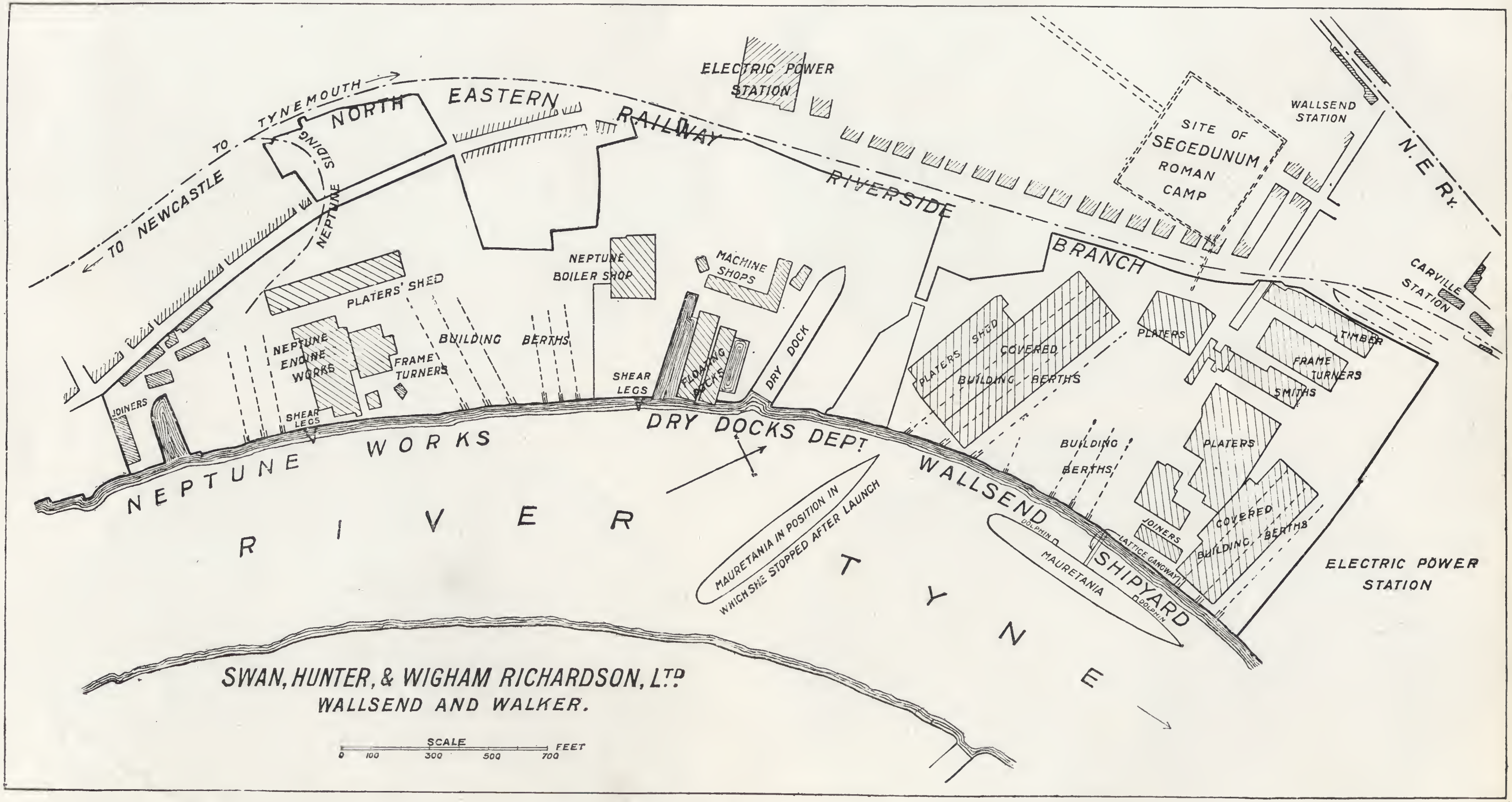


Fig. 16.—Plan of Shipbuilders' Works.

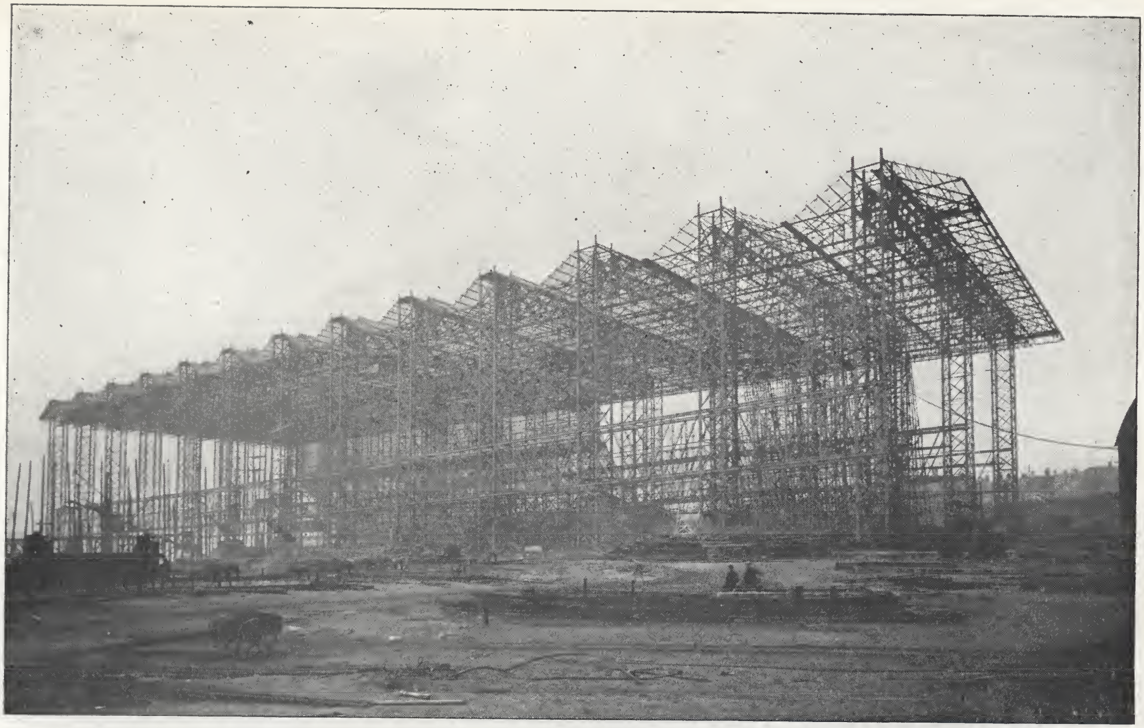


Fig. 17.—The Shipbuilding Sheds.

Fig. 18.—Main Joiners' Shop at Wallsend Shipyard.

in connection with the strength, stability and other investigations connected with the design of the steamer. Mr. Wurl had charge of the long series of experiments made with the experimental launch hereafter referred to. Mr. C. Stephenson is the yard manager at Wallsend, and upon him fell a large part of the great responsibility of the building, launching and completion of the vessel.

The work of construction was supervised on behalf of the Cunard Company by a shipbuilding committee composed of the directors, Mr. William Watson, Mr. M. H. Maxwell and Mr. J. H. Beazley in particular taking an active part. Of the Cunard Company's officials most closely associated with the building of the vessel, mention should be made of Mr. James Bain (general superintendent), Mr. L. Peskett (naval architect), and Mr. G. Thompson (engineering superintendent); while Mr. L. G. G. Demarest surveyed the vessel on behalf of Lloyd's Register and the Cunard Co. The intimate knowledge of Atlantic requirements, coupled with ripe experience and judgment, which these four gentlemen placed ungrudgingly at the disposal of both the ship and engine builders, contributed largely to the success achieved. The interests of the Admiralty were watched by Mr. C. G. Hall, a member of Sir Philip Watts' staff.

Before commencing the building of the vessel, the shipbuilding company proceeded to effect large extensions and improvements in the equipment of the Wallsend Works, which had already led the way in the introduction of improved buildings and machinery. Two new building berths, capable of accommodating ships of the largest class, were laid out. The position of these berths may be seen from the plan of the shipyard, Fig. 16. They are covered by glass-roofed sheds 150ft. in height, with a clear width of about 100ft. The present length is about 750ft., but this can be increased at any time to 900ft. The appearance of these sheds is illustrated in Fig. 17, and in the section of the shipbuilding shed given in the article dealing with the construction of the hull. In the roof under which the *Mauretania* was built, seven electric overhead revolving cranes have been provided. Some of these cranes have a capacity of three tons, and others five tons, while for lifting heavier weights, up to ten tons, they are arranged so that two can be worked in conjunction. These sheds and their appliances were invaluable in the construction of the vessel, work having been

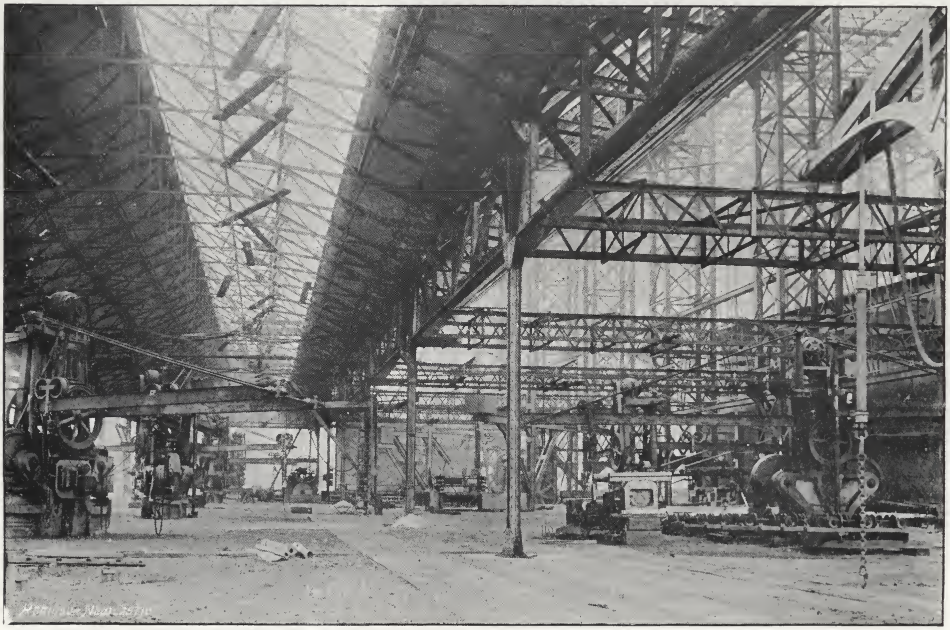


Fig. 19.—The Machine Shed.

proceeded with under all conditions of weather. All weights were economically handled; and the beams—some of them 88ft. long—which would otherwise have had to be rolled in two lengths and scarphed, were put on in one length.

Adjoining the covered building berths, large sheds were erected containing the most powerful and up-to-date machinery (see Fig. 19); and here practically the whole of the steel work for the vessel was dealt with. Another new group of sheds was built, containing all the latest appliances for preparing frames and floors of the largest size. The furnaces, 70ft. long, are gas-heated by an arrangement which enables a uniform temperature to be obtained over the whole length. Electric overhead cranes were installed for lifting the frame bars on the boards and bending slabs. Railway sidings, having direct connection with the North Eastern Railway Company's system, were added, enabling materials arriving by rail to be brought direct to the building berth or water-side. The joiner and wood-working departments were increased. Some idea of the main joiners' shop may be obtained from the photograph (Fig. 18) which we reproduce. It was necessary to dredge the river opposite the shipyard, and make special arrangements for mooring the vessel. For the latter purpose two large "dolphins" were provided, and for communication between the quay and the ship a large gangway was constructed

Fig. 20.—Workmen leaving the "Mauretania."

of girder lattice work. The dolphins and the gangway may be clearly discerned in the bird's eye view of the vessel given in the article describing the construction of the hull. For lifting the machinery and boilers on board, the shipbuilders provided the large self-propelling floating crane, capable of lifting 150 tons, which is also illustrated elsewhere. This crane, it may be mentioned, has proved most useful for lifting heavy weights all up and down the Tyne, besides dealing with the *Mauretania's* machinery.

It will thus be seen how complete the equipment of the Wallsend Shipyard is; and, as now laid out, it is unsurpassed by any other shipbuilding works in the world.

It may be of interest to add that the *Mauretania* was built on the site of the important Roman stronghold of Segedunum, which existed from about the year 280 to 400 A.D. Segedunum marked the easternmost end of the great Wall built by the Romans and which spanned Britain from the Solway to the Tyne. During excavations in the Wallsend Shipyard shortly before the laying of the keel of the vessel, a portion of the Wall was uncovered (see Fig. 21), and many coins and other proofs of the occupation of Britain's ancient conquerors were unearthed.

Fig. 21.—Fragment of the Roman Wall in Wallsend Shipyard.

Building of the Hull.

Dimensions.

THE following are the leading sizes of the vessel as constructed:—

TABLE II.—DIMENSIONS.

Length over all	790′ 0″
Length between perpendiculars	760′ 0″
Breadth extreme	88′ 0″
Depth moulded to shelter deck at lowest point of sheer	60′ 6″
Assigned freeboard	25′ 1½″
Draught to assigned freeboard...	36′ 2½″
Gross tonnage	31,938
Registered displacement	44,640

A comparison of the foregoing information with the table of dimensions of other vessels given on page 2 will show that the *Great Eastern* was 80 feet shorter and nearly 7,600 gross tons less; the *Deutschland* is nearly 100 feet shorter and practically 15,500 tons less; the *Kaiser Wilhelm II.* and the *Kronprinzessin Cecilie* are each 82 feet shorter and 12,550 tons less; and the *Lusitania*, with the same length but with a depth moulded 6 inches less, has a gross tonnage 1,116 short of the *Mauretania's*.

❋ ❋ ❋ ❋

Structural Design.

THE structural design of the *Mauretania* is shown by the midship section (Fig. 22) and the profile on Plate V. There are seven decks amidships—the lower, main, upper, shelter, promenade, boat and sun decks; while at the ends, two extra decks—known as the orlop and lower orlop—are fitted, making nine decks in all.

From aft to about 80 feet forward of amidships the main structure of the ship ends at the shelter deck. For the remaining portion of the fore body, the side plating is extended to the promenade deck, forming a long forecastle; and the material at this part has been more economically distributed by increasing the scantlings of the forecastle deck and side plating and decreasing those of the parts below. Provision has, of course, been made to maintain the full strength at the break. Owing to the light scantlings of the erections above the promenade deck, the former have been provided with three expansion joints to prevent heavy stresses coming upon the thin plating in a seaway. The plating of the promenade deck and of the deckhouse sides on the shelter deck is of a more substantial character, and these have been made continuous as far aft as the main mast, as shown on Plate V. The expansion joints are covered by a brass plate, as shown in Fig. 23, and made watertight inside the houses by a leather strap. Where the under side of the deck is exposed to the weather an open scupper channel is fitted in lieu of the leather.

To increase the width of promenade space, the promenade and boat decks, where open at the sides, have been extended 20 inches beyond the line of the shelter deck, but they do not project beyond the greatest breadth of the vessel.

The forward portion of the house between the promenade and boat decks has been extended to the sides of the vessel, and the front strongly constructed of a rounded form, in order to withstand the impact of the heavy seas, which experience has taught will sweep over the forecastle deck of such a high-speed vessel in stormy weather. The plating of the front is 1 inch thick and has been strongly stiffened, as shown in Fig. 24.

The keel consists of three thicknesses of plating. No buttstraps were fitted to the keel plates, as the sectional area lost at a butt did not exceed that cut away by the frame rivet holes. The maximum stresses, too, at this part are compressive. Outside buttstraps, besides increasing the draught, would have been very inconvenient when docking.

The bottom plating was arranged clincher-fashion to permit hydraulic riveting, and the frame bottoms were joggled to avoid the use of tapered packing pieces. The number and weight of butts and overlaps were minimised by using plates of very large size. The shell plates and heavier plates on the decks were in most cases 35ft. long and weighed 2½ to 3 tons

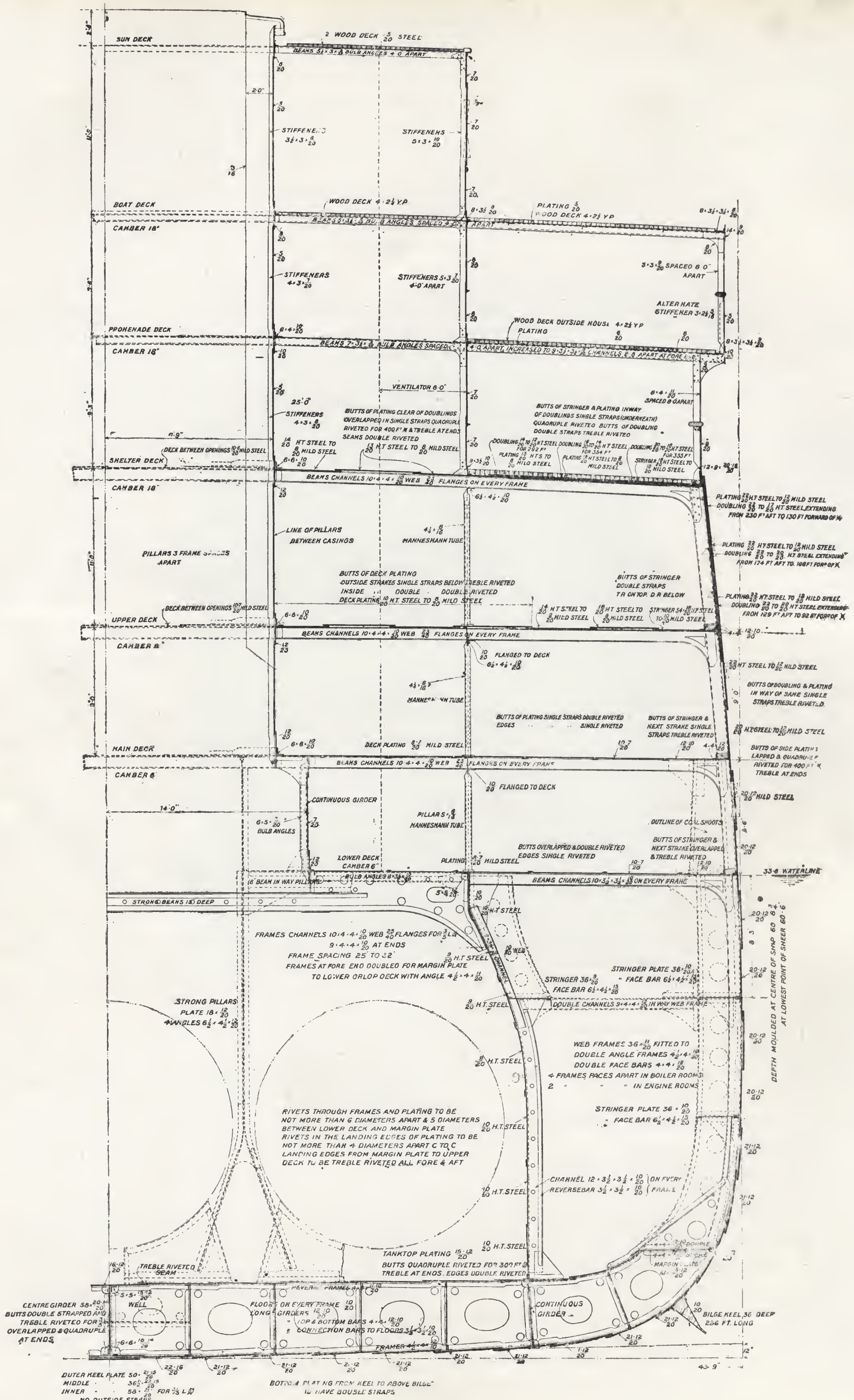


Fig. 22.—Midship Section

each. In some cases, however, the length of the plates was 48ft. with a weight of 4 to 5 tons, a record size for ship plates of this description. The butts of the bottom plating up to the bilge have double straps, the inner strap taking three rows of rivets at each side of the butt, and the outer strap taking two rows of rivets, while the seams were double riveted. The edges of the outside straps were chamfered to reduce eddies. Above the bilge, the butts were overlapped and quadruple riveted for 400ft. amidships and the seams were treble riveted throughout. The seams of the plating between the upper deck and the shelter deck were again arranged for hydraulic riveting, the butts at this part having single treble-riveted straps.

A cellular double bottom, extending well up the bilge, with floors on every frame, is fitted throughout the vessel, 5ft. deep in the boiler rooms and holds, and 6ft. deep in the engine space. It contains five continuous longitudinal girders, *viz.*, the centre keelson, the two tank margin plates, and the fifth or E girder on each side, the remaining girders being intercostal.

The frame spacing is 32in. amidships, reduced to 25in. aft and 26in. forward. The framing consists of 10-in. channel bars and deep web frames generally 10ft. 8in. apart. In the engine room the web frames are close-spaced, but are somewhat reduced in width. The channel bars extend from the margin plate to the shelter deck, some of these bars having a total length of about 55ft. and weighing about three-quarters of a ton. The deck beams are also of channel section, and have turned knees, for the sake of lightness.

The pillaring arrangement in the 'tween decks consists of four rows of Mannesmann tube pillars, spaced about 8ft. apart, with deck girders supporting the intermediate beams. In the boiler rooms the two outer rows are carried by the longitudinal side bunker bulkheads, while the inner rows are carried by the continuous girders formed by the casing sides between the lower and main decks. These girders are double riveted throughout, and are each supported by the main and partial bulkheads and by two strong pillars in each boiler room. The large stokehold ventilating trunks, which rest at their lower ends upon the bulkheads and are continued in one length to the sun deck, give great vertical as well as lateral rigidity. As the ship gets narrower at the ends, the number of rows of pillars is reduced. Two strong beams are fitted at the lower deck level in each boiler room to maintain the structural strength at this part.

The engine seatings are built on top of the cellular double bottom, and have been specially designed to ensure great transverse as well as longitudinal rigidity. The longitudinal bulkheads form a valuable additional support. Some idea of their construction may be gained from the section through the L.P. and H.P. turbine seatings shown in Fig. 25.

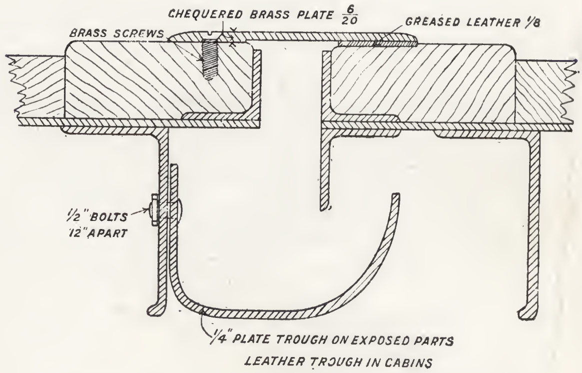


Fig. 23.—Section through Expansion Joint.

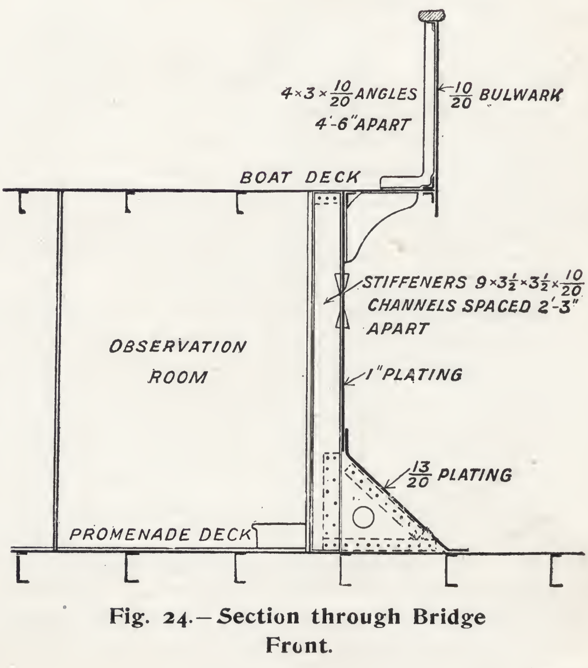


Fig. 24.—Section through Bridge Front.

All exposed decks are sheathed with yellow-pine; but in way of enclosed passenger accommodation, certicene has been adopted to save weight. In order to obtain a flush surface for laying this material, seam strips and butt straps have been fitted below the deck to all connections where the deck plating is comparatively thin; while in the case of the thick structural decks, where the seams are overlapped, the inside strakes have been levelled up with bitumastic cement supplied by Messrs. Wailes, Dove & Co. The same firm's bitumastic coverings have been applied to all those parts of the steel structure subject to a large variation in temperature, in order to prevent corrosion. The steel surfaces thus coated included the coal bunkers, the floors, intercostals and tank top of the cellular double bottom under all the engine and boiler compartments, and the boiler, turbine and auxiliary engine seating. The bottom of the vessel has been coated with both Holzapfel's anti-corrosive and anti-fouling compositions.

* * *

Riveting. Mild steel rivets have been used throughout the structure, even for connecting the high-tensile steel plates. Sufficient experience had not been gained with the use of high-tensile steel as a material for rivets to warrant its adoption for this purpose. It was considered preferable, therefore, to use mild steel and maintain the necessary strength at the butts by increasing the rivet area and using hydraulic riveting machines of great power. Rivets of the size and number required for mild steel plates, equivalent in strength to the high-tensile steel plates, were used, and the sharp edges of the holes in the plates were removed by a special tool, to minimise the shearing effect of the plates upon the mild steel rivets. Hydraulic riveting was adopted for the keel plates, centre keelson, garboard strakes, and shell plates within the range of the double bottom, also for the connection of shell to stem and stern castings, floors, frame bottoms and top bars, tank girders, web frames, reverse bars to frames and tank side knees, the girders forming the engine seating, the topside plating and doublings for a length of about 520ft. amidships, and the shelter deck stringer and doublings for a length of about 440ft. amidships. Eight hydraulic riveting machines were employed, supported by trolleys running in the roof of the shed under which the vessel was built, and also from derricks guyed from the standards of

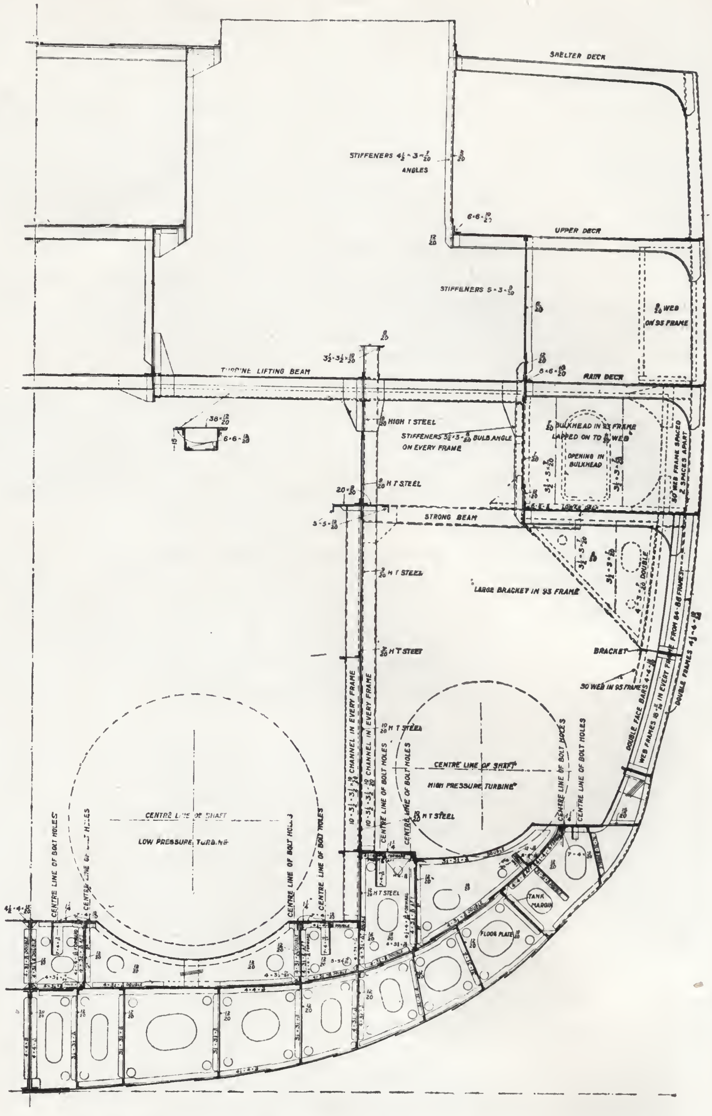


Fig. 25.—Section in way of Engine Room, showing Turbine Seating.

the building shed, as shown in Fig. 26. Upwards of four million rivets were used in all, weighing fully 700 tons. The rivets were heated in oil furnaces which were specially designed at the Wallsend Shipyard.

* * * *

Stem and Stern Castings.

The stem bar is of forged ingot steel rabbeted to take the shell plating, and connected by a steel casting to the centre keelson and the keel of the ship. The stern frame and brackets for supporting the propeller shafts are of cast steel, their design and connection to the hull being clearly shown in Fig. 27. An idea of the large scale upon which these castings had to be designed may be gathered from the weights, which are given in the following table:—

Table III.—Weight of Castings.

Main portion of stern frame	48 tons
Upper ,, ,, ,, ,, ...	6 ,,
After brackets, each	23·5 ,,
Forward brackets, each	24 ,,
Heel casting....................................	9 ,,
Rudder, including stock and pintle ...	64 ,,

All these were supplied by the Darlington Forge Co.

The rudder, which is of the balanced type, is made of steel castings bolted together. It consists of three pieces, in addition to the

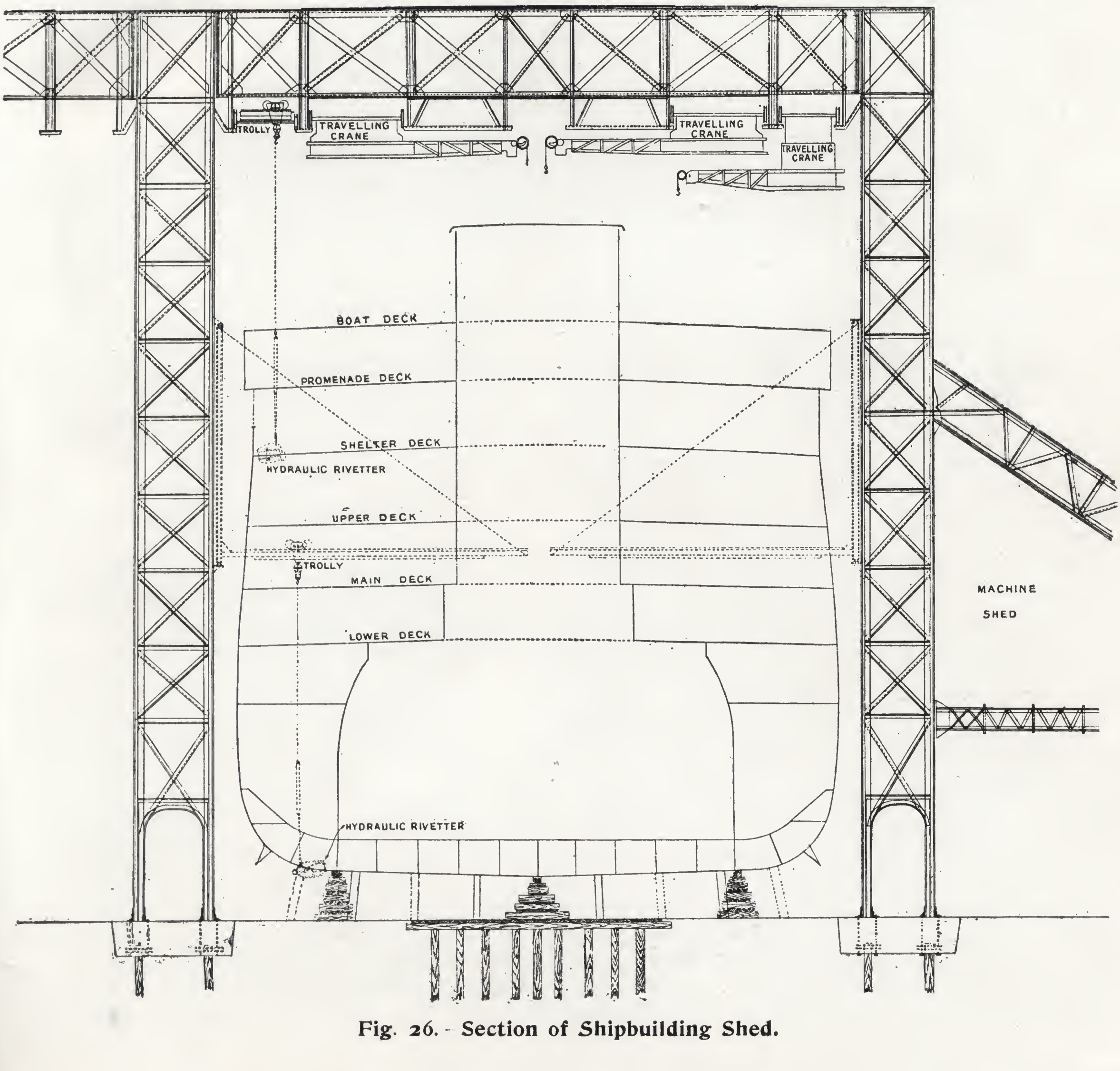


Fig. 26.—Section of Shipbuilding Shed.

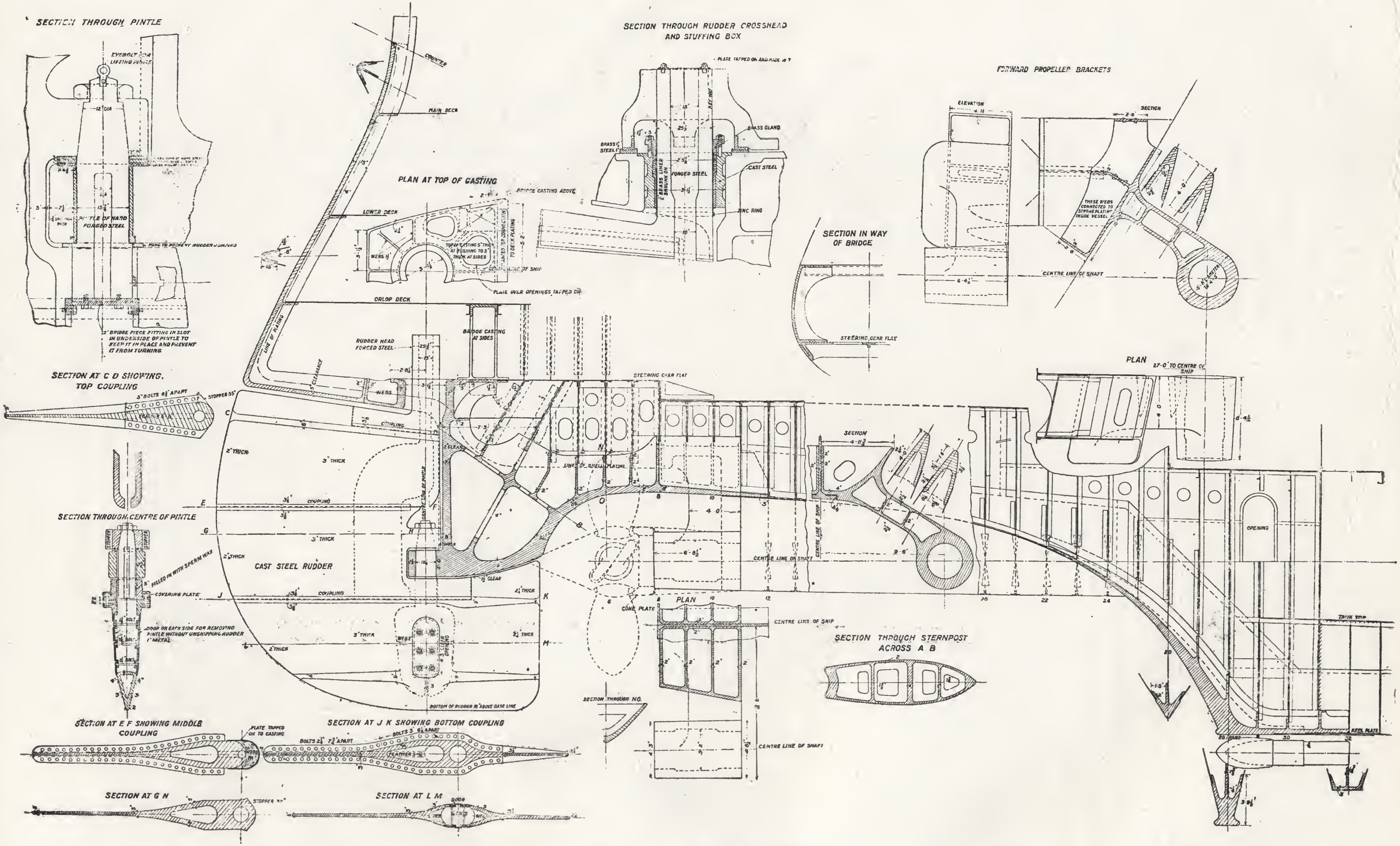


Fig. 27.—Stern Castings.

forged ingot steel rudder-head of $25\frac{1}{2}$in. diameter. An unusual feature of the rudder is the design of the pintle. There being only one gudgeon on the stern frame, the pintle had to be made of very large size although in double shear, its weight being over $1\frac{1}{4}$ tons. By the ingenious arrangement shown in Fig. 27, it is possible to withdraw the pintle and replace the bushings without disconnecting any part of the rudder or the steering gear.

main deck. Transverse bulkheads are fitted right across the ship at the end of each boiler room, extending to the upper deck; and intermediate transverse bulkheads extending to the main deck are fitted in the wing bunkers dividing the latter into short compartments. In addition, the lower deck, except in No. 3 boiler room, is made watertight throughout; and the main deck is also made watertight over the engine and boiler space.

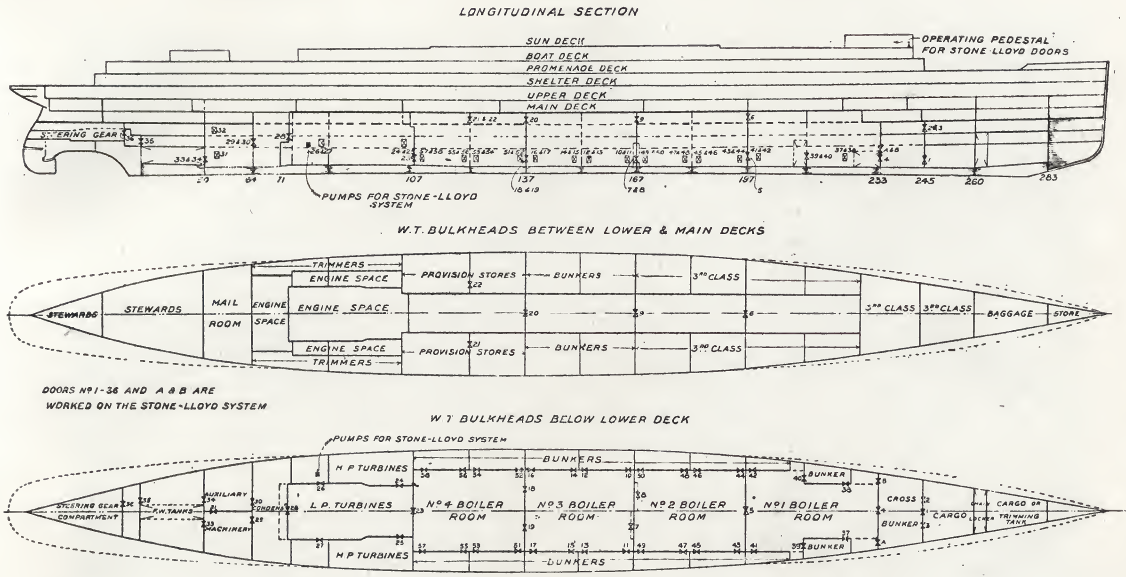


Fig. 28.—Watertight Sub-division.

Watertight Sub-division.

THE sub-division by watertight bulkheads and decks is most elaborate, there being no less than 175 separate watertight compartments. The arrangement of these is clearly shown by Fig. 28. The extension of the cellular double bottom up the bilge affords great additional protection in the event of the liner grounding, and the centre girder forms a watertight centre division for the greater part of the length to provide facilities for trimming the vessel. The longitudinal bulkheads forming the side bunkers below the lower deck, and the casing sides between the lower and main decks, are made watertight for their full length throughout the boiler space; while two longitudinal watertight bulkheads are fitted in the main engine space extending well above the

The most elaborate watertight subdivision would, however, be useless if no arrangement were provided for promptly closing the watertight doors through the bulkheads in case of accident. The doors in the main hold bulkheads, therefore, have been fitted with the Stone-Lloyd system of closing, whereby they can all be closed in a few seconds, from the captain's bridge. The system is worked by hydraulic power, two special pumps being fitted in the engine room for this purpose. From the pumps a pressure main is led to a powerful hydraulic cylinder attached to each door, while each door is connected to a small pipe (the closing main) controlled from the operating pedestal. By means of the latter, pressure is put into the closing main, the controlling valves are reversed and

pressure admitted into the cylinders operating the doors, and at the same time a powerful gong is rung. Should members of the crew be shut in a compartment, they can open the door by means of a lever placed on each side of the bulkhead. They cannot leave the door open, as it closes automatically behind them. An automatic indicator is placed on the bridge and shows the position of each bulkhead door. When the door is closed, a small coloured disc showing the number of the door is illuminated, the light going out immediately the door is opened. Altogether 38 watertight doors are fitted with the Stone-Lloyd system, including the doors in the side bunker bulkheads in No. 3 boiler room, where the lower deck at this part is not watertight. The remaining side-bunker compartments being only small, the watertight doors are of the ordinary sliding pattern, worked by rods from the shelter deck, with a dial which shows whether they are closed or open. The general appearance of the Stone-Lloyd door is shown by Fig. 29, which is a photograph of the door in the centre stokehold of No. 3 boiler room.

* * * *

Building Stages. As already mentioned, the construction of the forward portion was proceeded with first, pending completion of the engine room drawings, and the midship and forward parts of the double bottom were erected as shown in Fig. 30. Fig. 31 illustrates the framing at the fore end completed and the bulkheads partly erected. This illustration clearly shows one of the hydraulic riveters in actual use for riveting the shell plating. Fig. 32 is a view taken from the after end of the vessel, with the frames in position in way of the engine and after boiler rooms. It also shows the strong beams connecting the two sides of the vessel where the

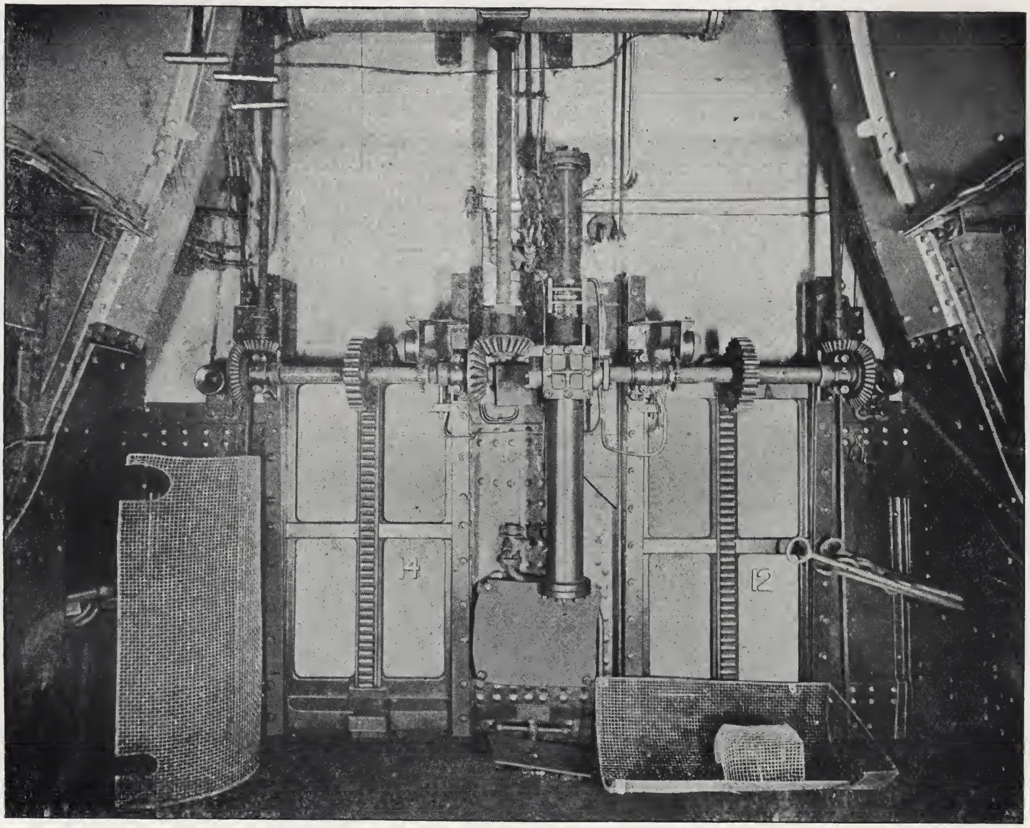


Fig. 29.—A Stone-Lloyd Watertight Door.

lower deck is cut away in the boiler rooms. Fig. 33 shows the interior of the after end of the vessel taken from the engine room, the trans-

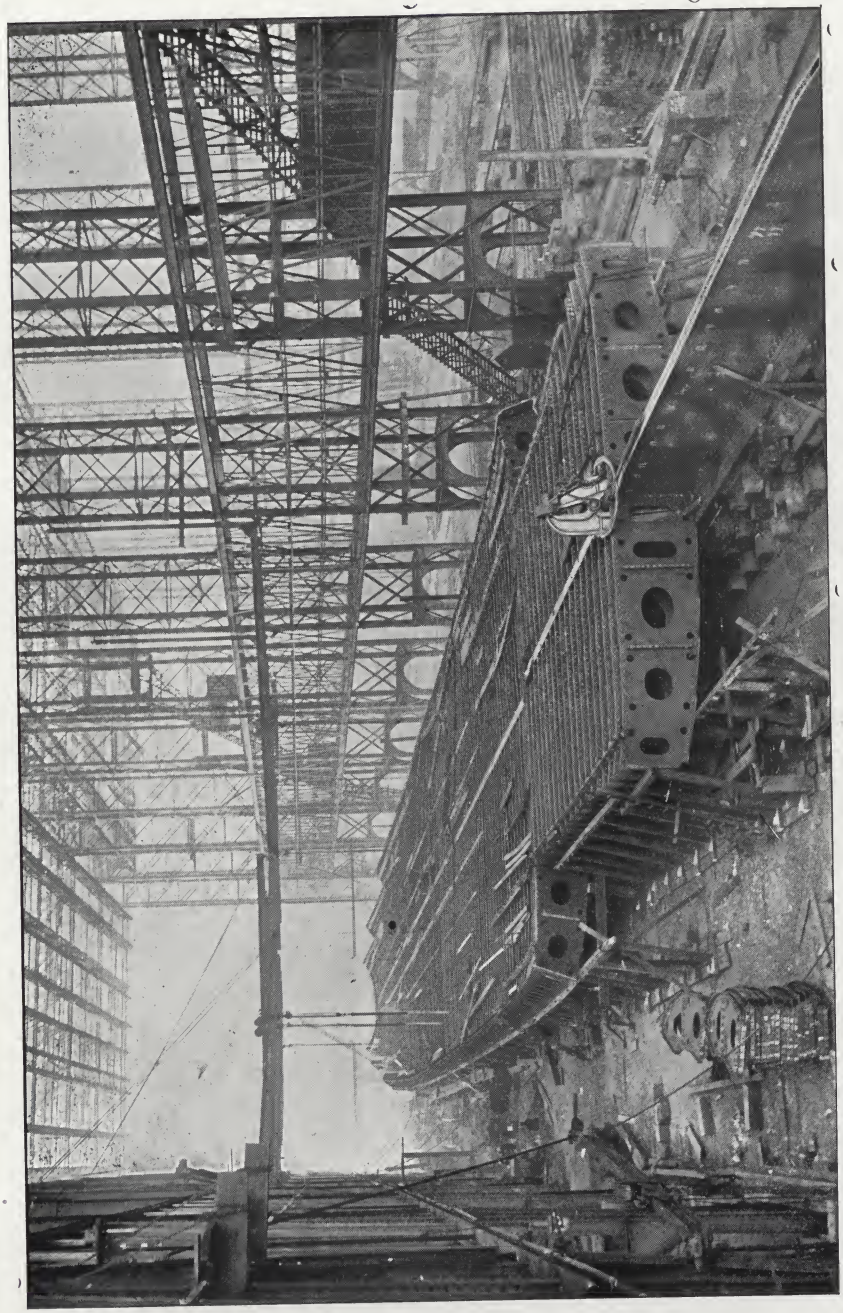


Fig. 30.—Midship and Forward Parts of Cellular Double Bottom

verse bulkheads not being in position. This view shows clearly the peculiar construction of the hull. In the foreground may be seen the frames bossed out for the wing or outer shafts, and to allow a fore and aft passage for the engineers to reach the shaft bearings, the web frames having been considerably increased in size and large openings provided for this purpose. Further aft we may observe the frames bossed

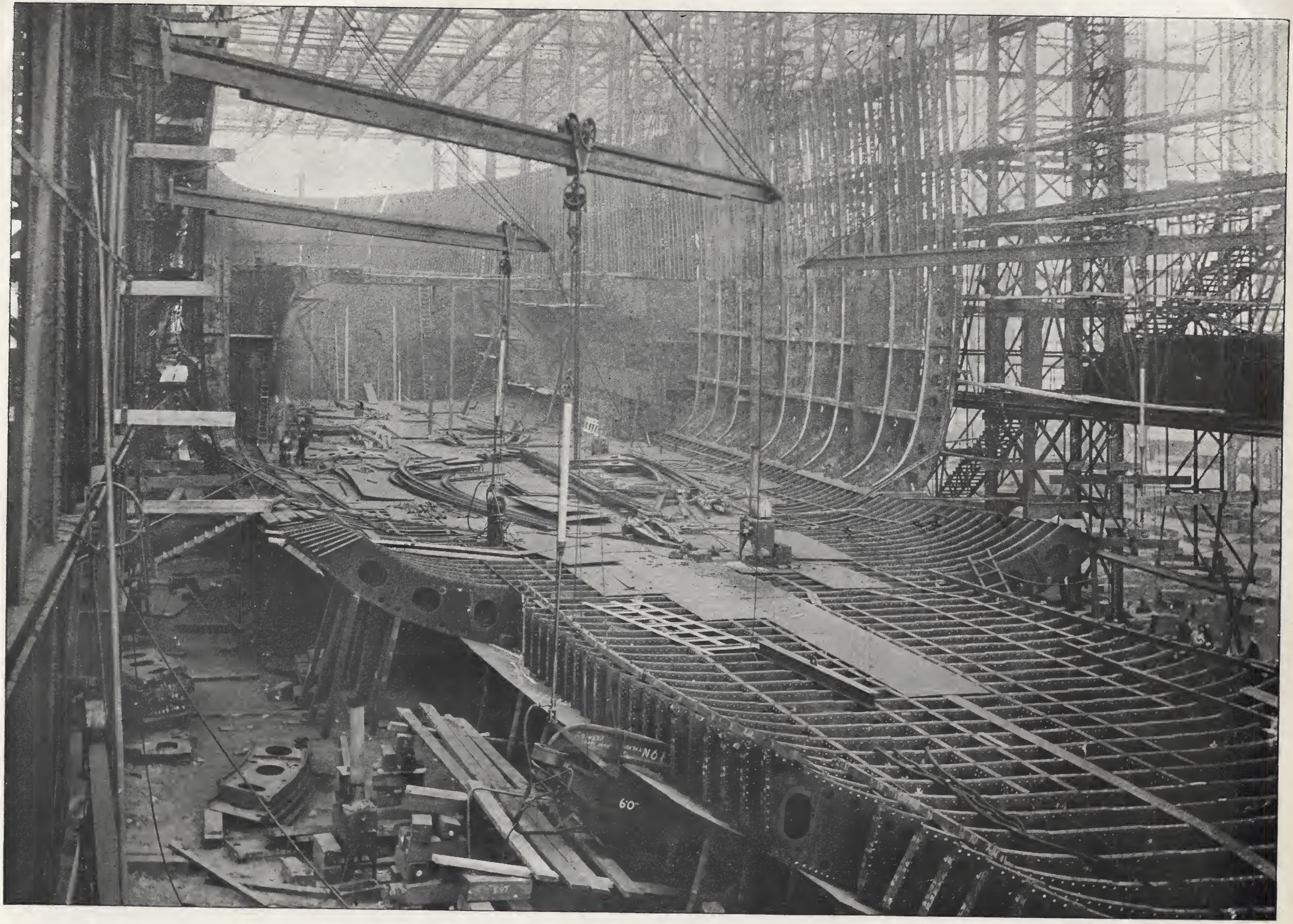


Fig. 31.—Framing at fore end completed.

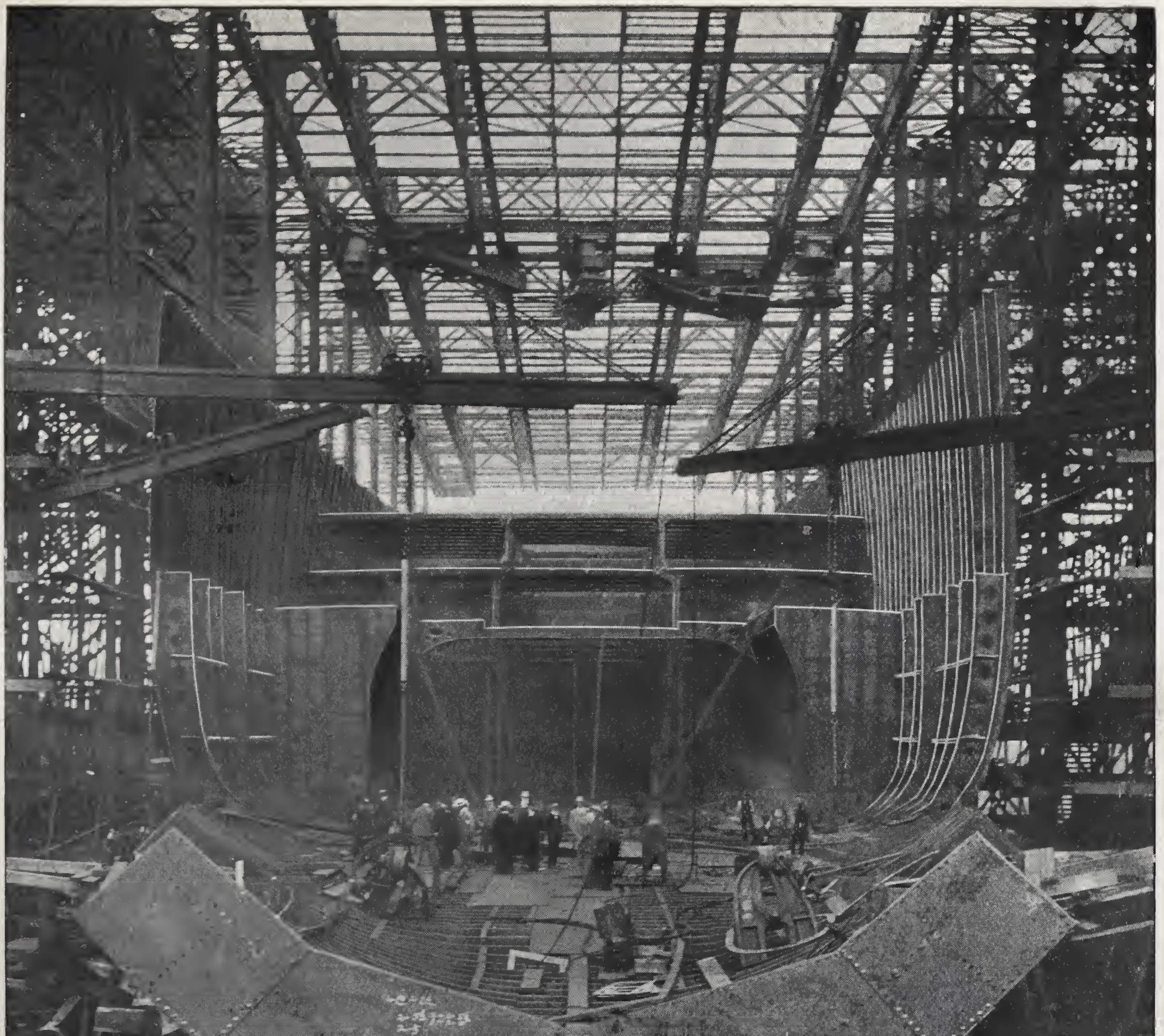


Fig. 32.—View looking forward from after end of Engine Room.

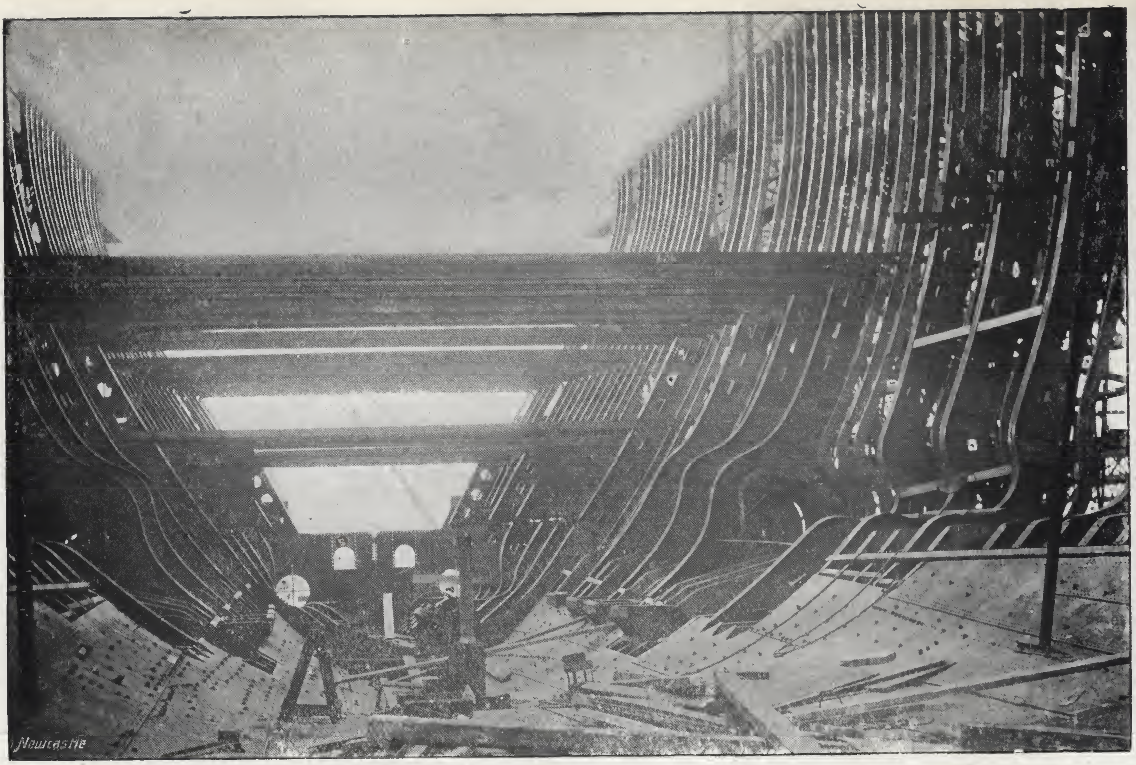


Fig. 33.—Interior of after end, from Engine Room.

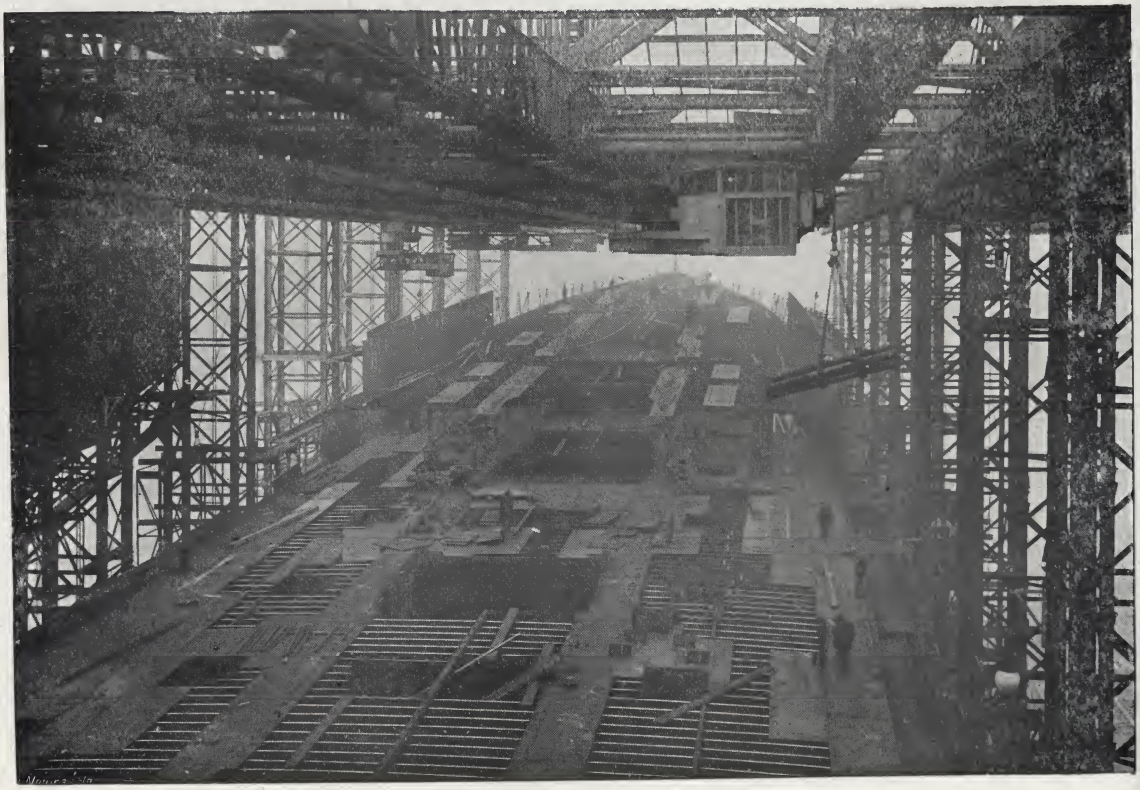


Fig. 34.—View looking down on Shelter and Promenade Decks.

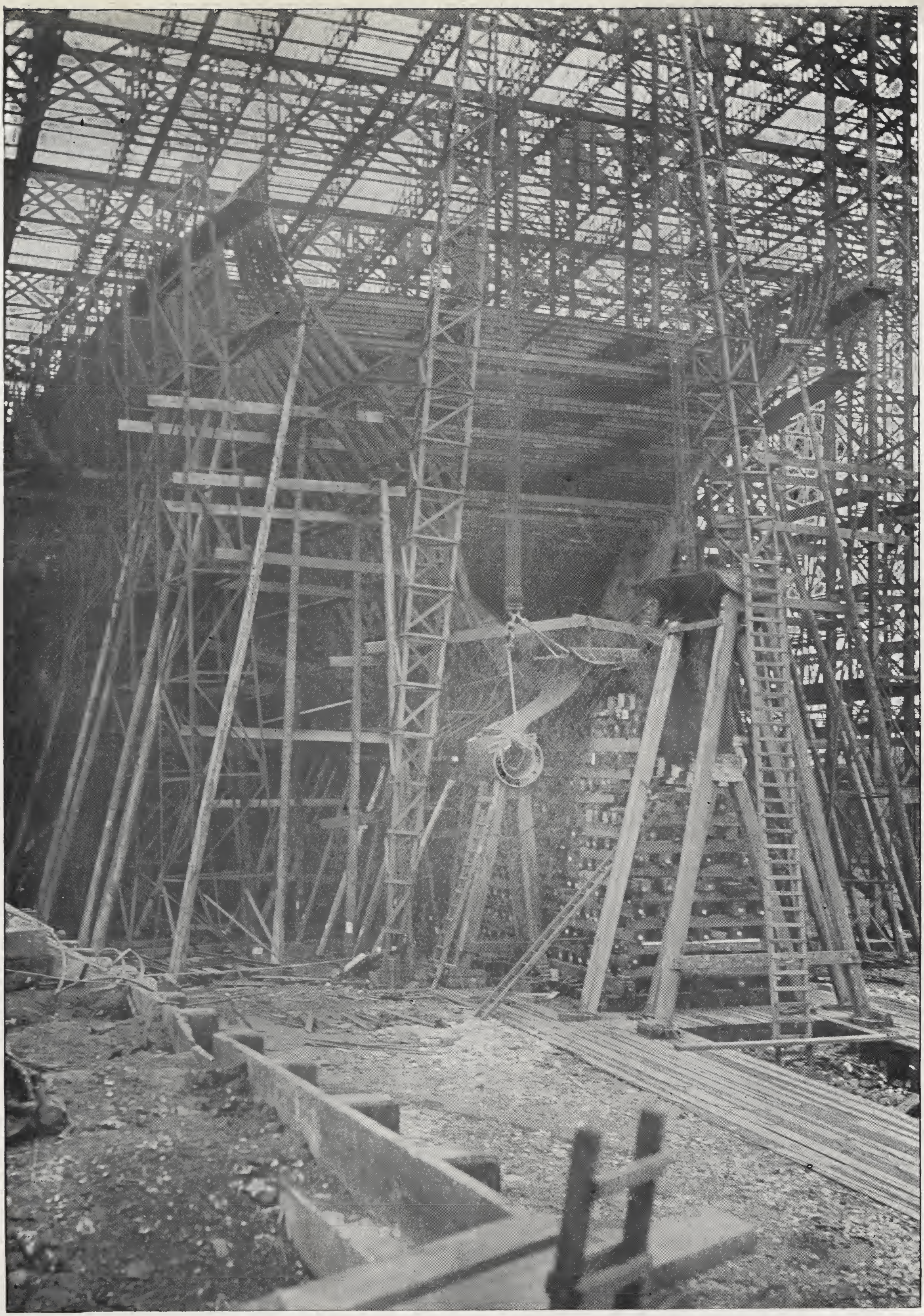


Fig. 35.—Framing at after end practically completed.

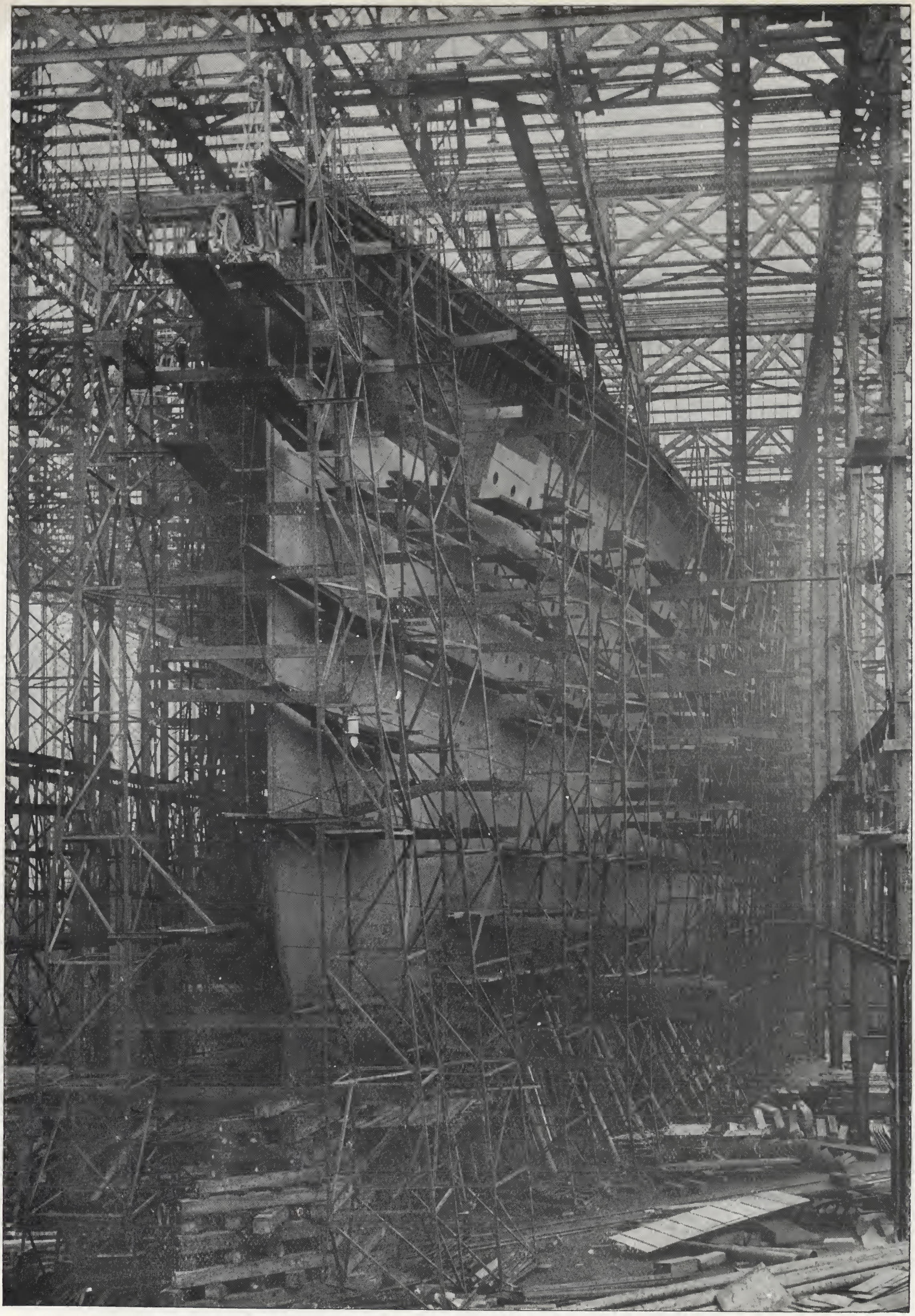


Fig. 36.—Shell Plating of Fore Body practically completed.

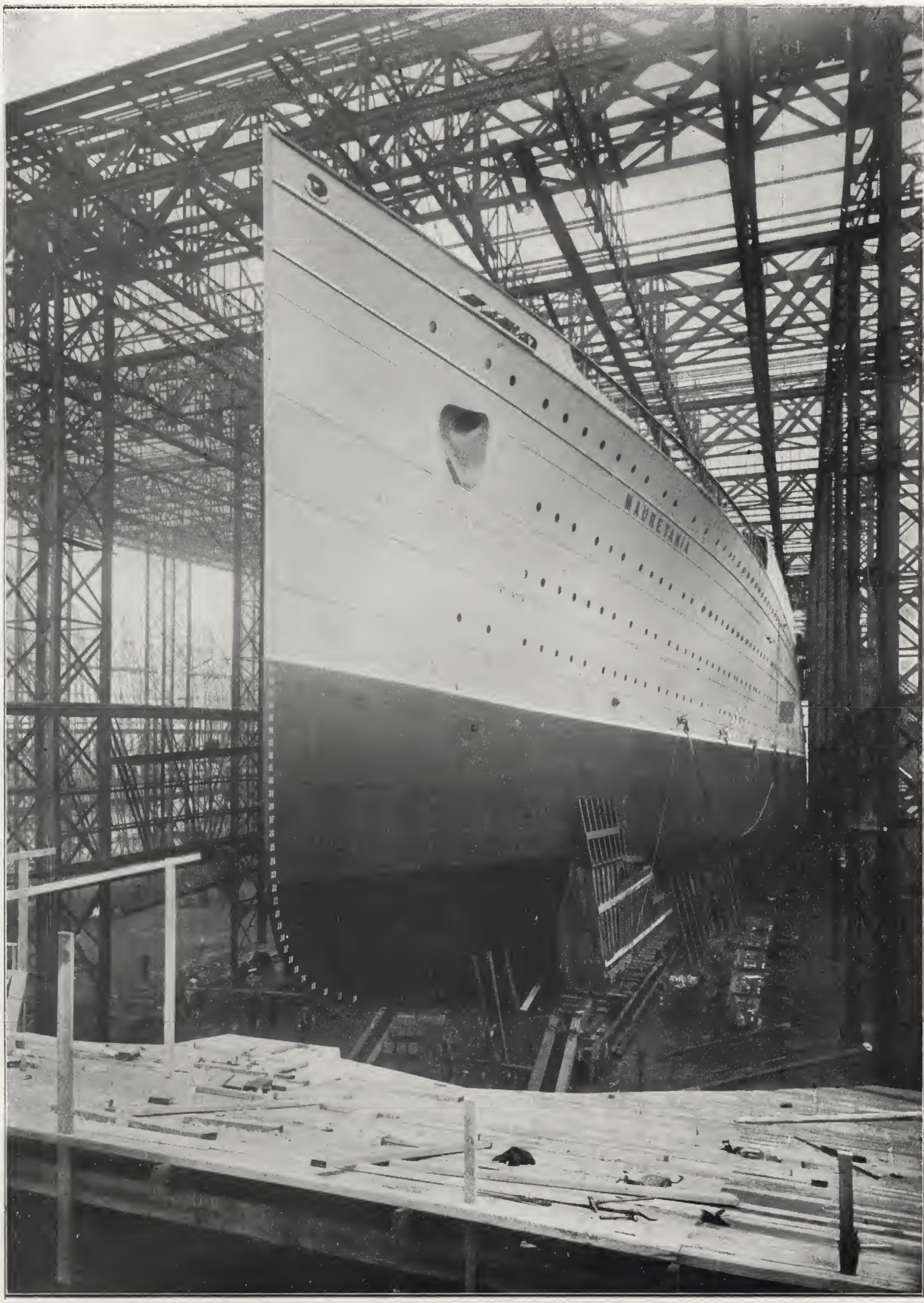


Fig. 37.—Bow View, before Launch.

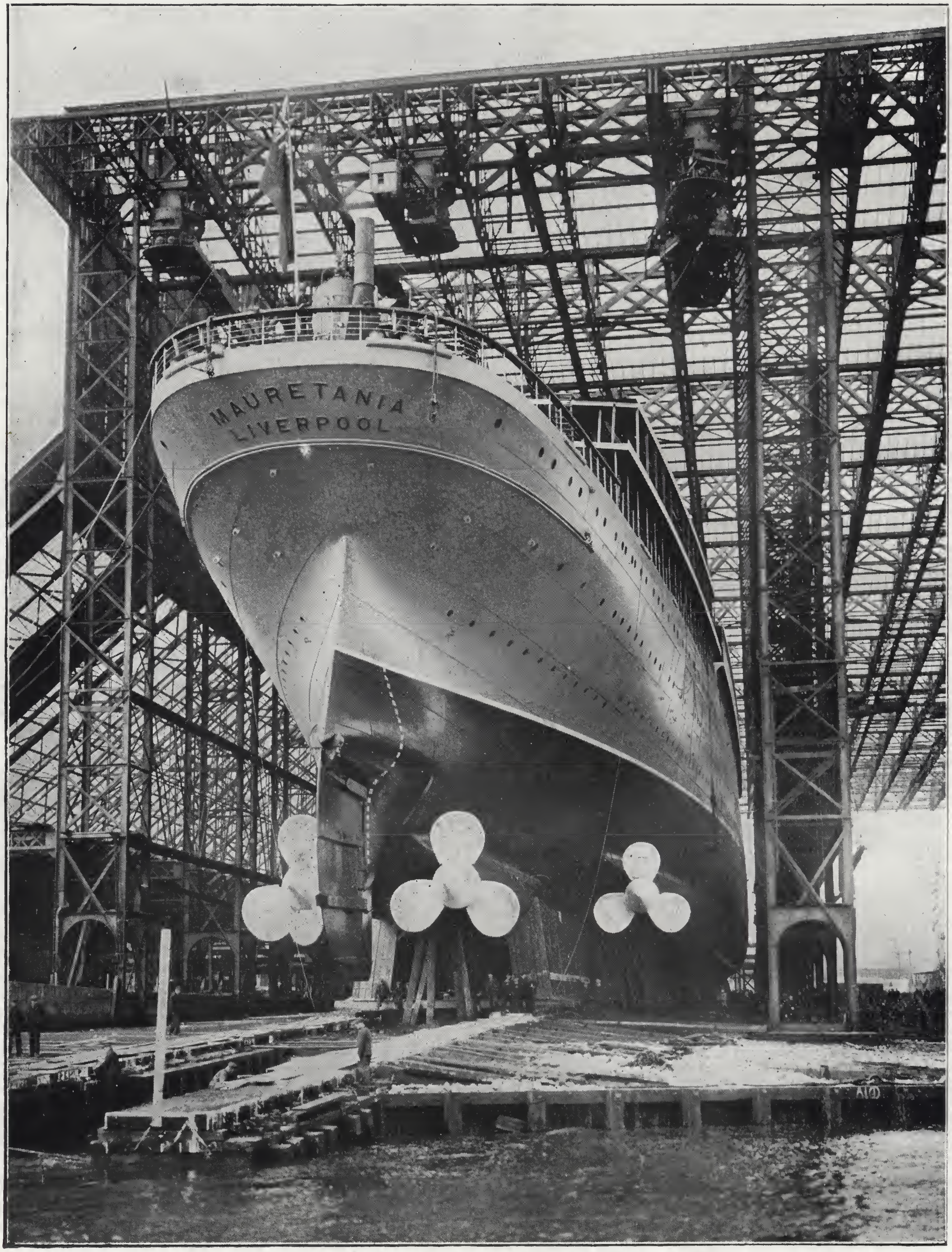


Fig. 38.—Stern View, before Launch.

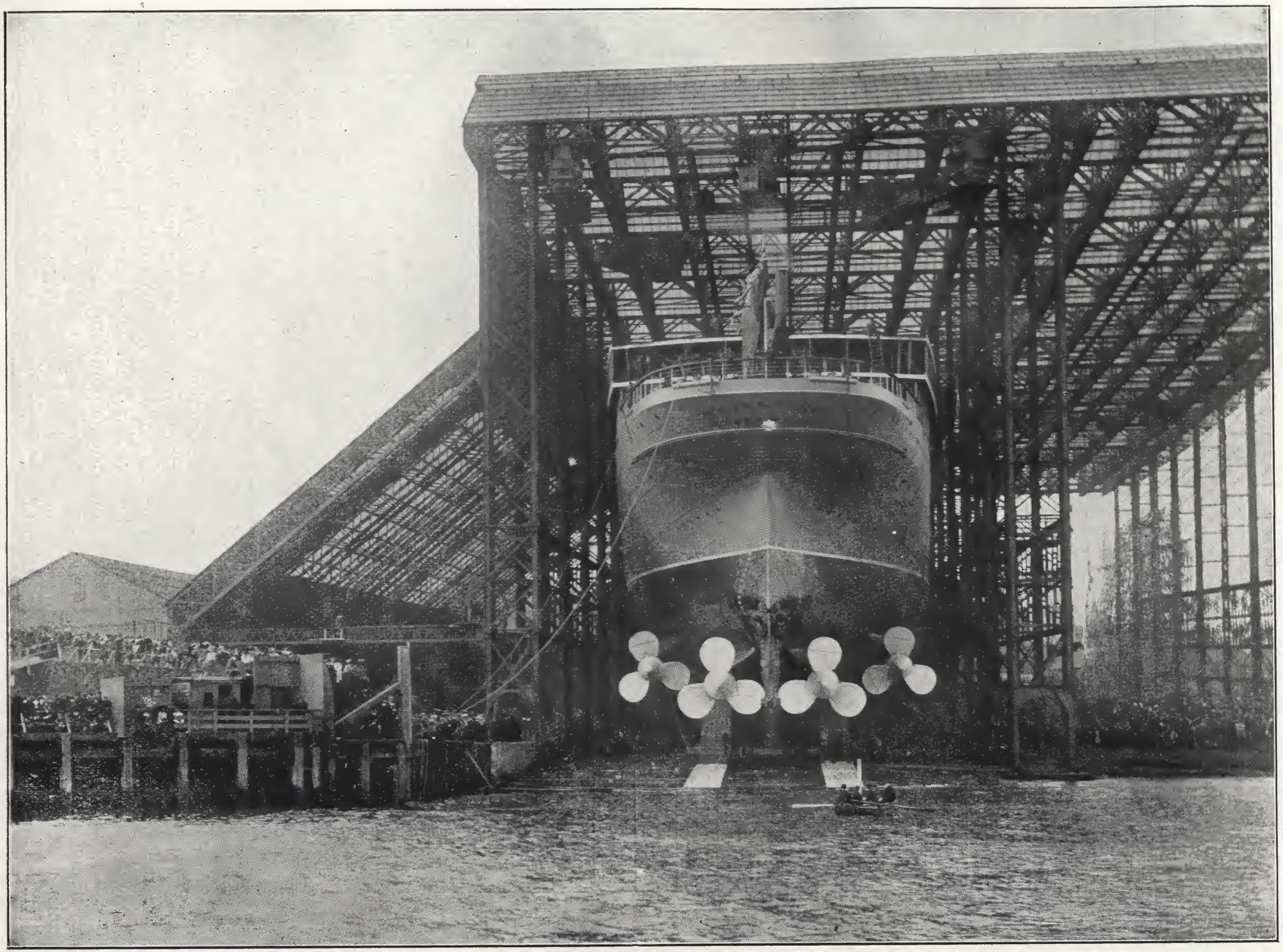


Fig. 39.—View showing four Propellers.

out for the inner shafts and the two openings through the after bulkhead for the tunnels. The top plating of the cellular double bottom at this part of the vessel extends well up the ship's side past the margin plate, affording, in addition to greater safety, a strong connection for the frame feet. Fig. 34, a photo taken at a later stage, illustrates the appearance of the vessel, looking down upon the shelter and the shell plating of the fore body practically complete. This view also shows a number of the shipbuilding firm's patent staging supports, composed of light angle bars with special staging, which were extensively used to facilitate the work and which were lifted into position as required, by the electric cranes. The final illustrations of the vessel on the stocks show a bow and stern view taken just

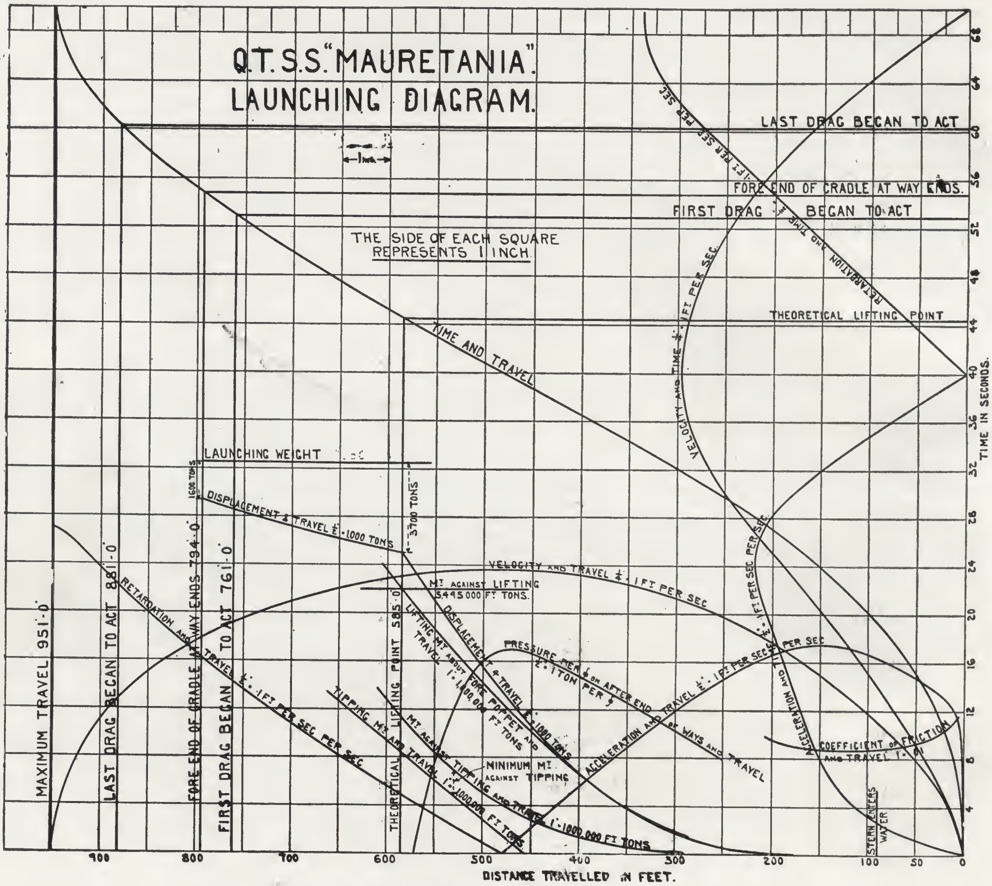


Fig. 40.—Launching Diagram.

promenade decks from the roof of the building shed. It will be seen that the beams are erected and the decks partially plated. The next view, Fig. 35, shows the framing at the after end practically completed, with the main stern frame and brackets erected, the large derricks used for this purpose being still in position. The work at the forward portion of the vessel is seen well ahead of the after part in our next illustration (Fig. 36), which shows before the launch (Figs. 37 and 38); and a further stern view, also taken just before the launch, is added (Fig. 39) to illustrate the four propellers. The last-named view shows very clearly the shipbuilding sheds and overhead cranes.

* * * *

Launch of the Vessel.

THE vessel was successfully launched on the 20th September, 1906, in the presence of an immense concourse of spectators, the

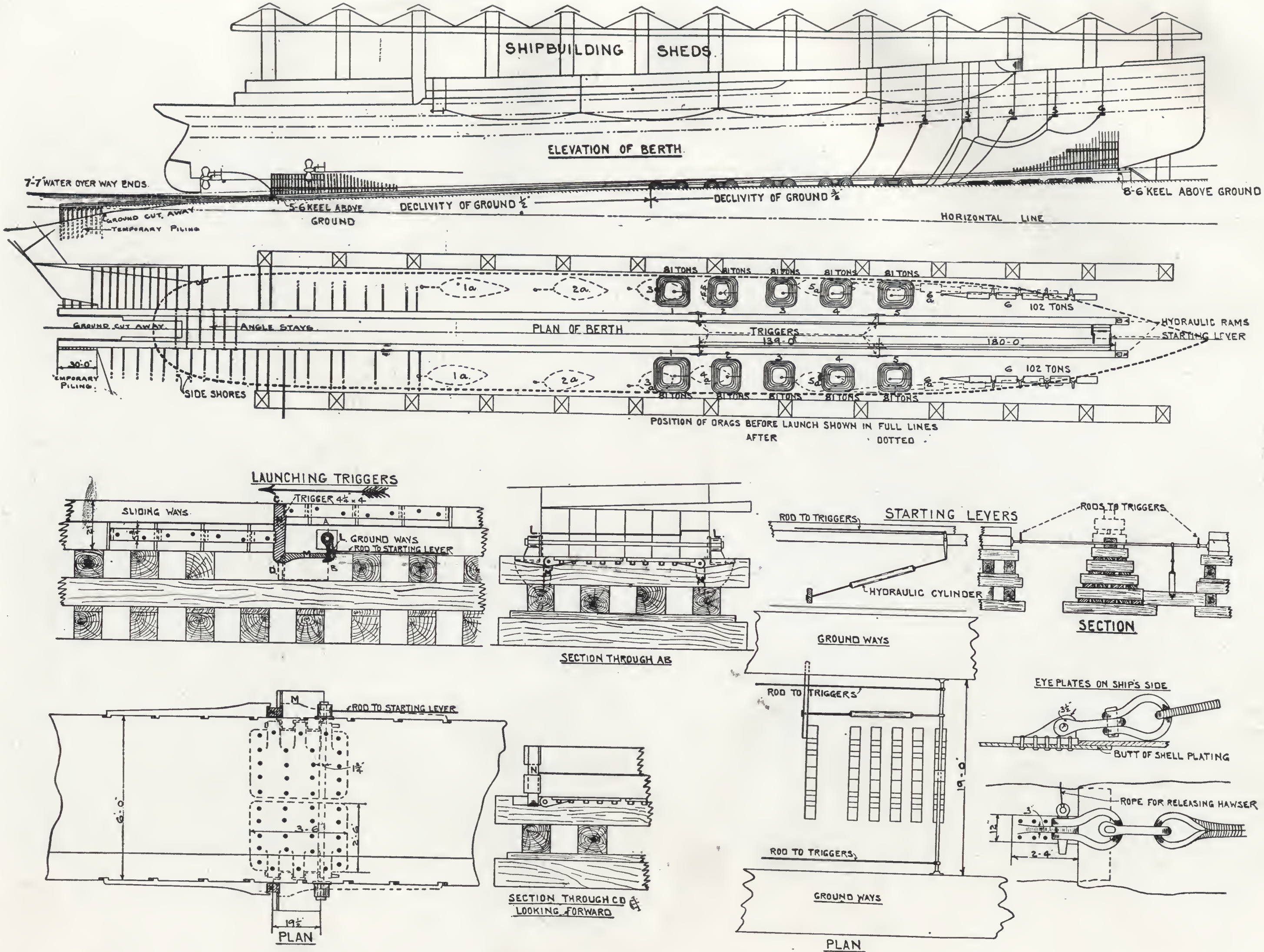


Fig. 41.--Launching Details.

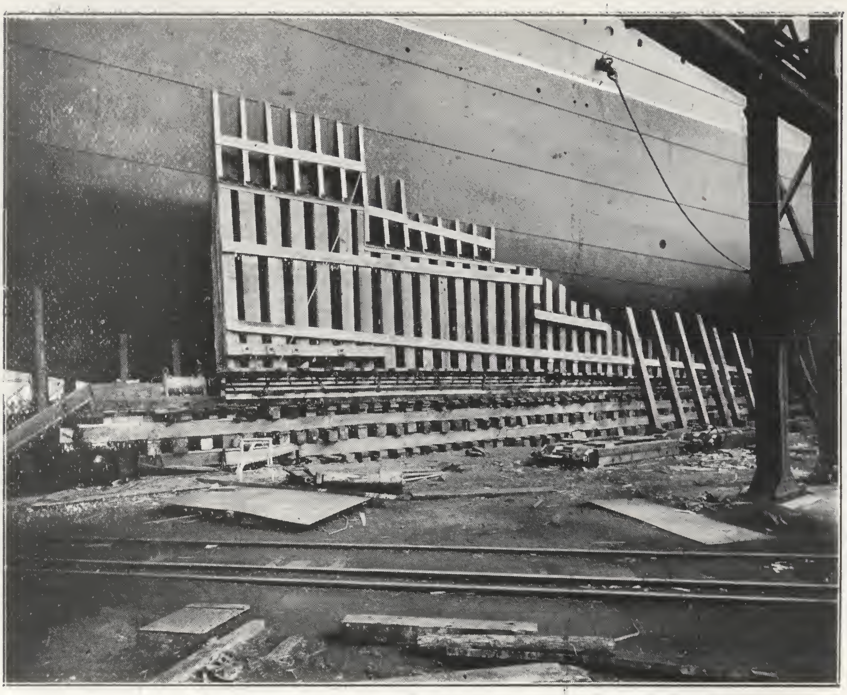


Fig. 42.—Forward Cradle.

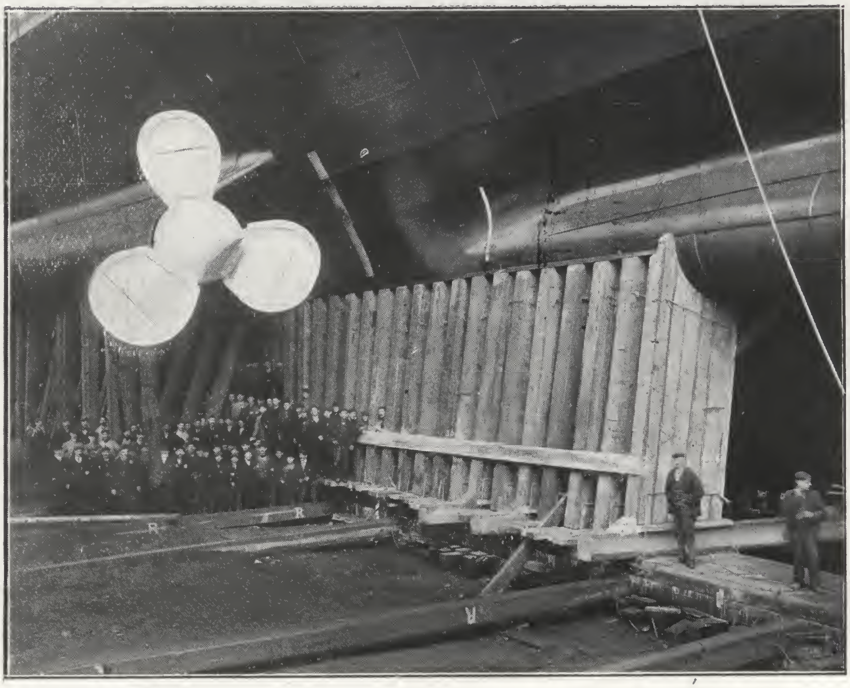


Fig. 43.—After Cradle.

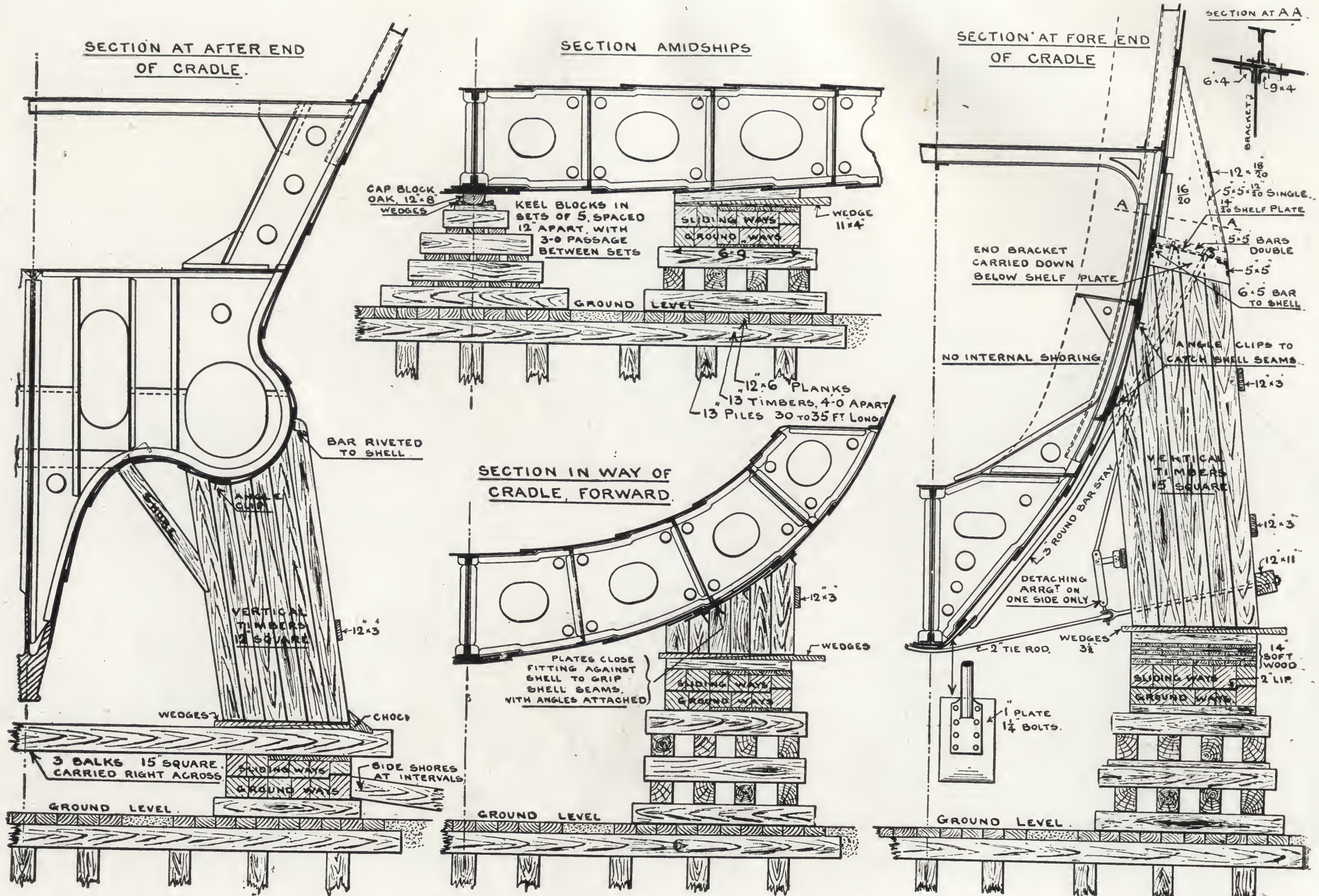


Fig. 44.—Sections through Launching Cradles.

naming ceremony being performed by the Dowager Duchess of Roxburghe. The launching arrangements, which were very complete and satisfactory, have already been very fully described and illustrated in the article on "The Launching of the *Mauretania*," by Mr. H. Bocler, published in 'The Shipbuilder," Vol. I., No. 4, to which we must refer our readers for a detailed description. From this article, however, we reprint the following table:—

Table IV.—Launching Particulars.

Length B.P.	760′ 0″
Breadth, extreme	88′ 0″
Date of launch	Sept. 20th, 1906, 4-15 p.m.
Wind	Light N.E.
Temperature of Atmosphere	64°F.
Draught ...	Forward, 11′ 7½″; aft, 21′ 4½″; mean, 16′ 6″
Weight of ship and launching cradle ...	...16,800 tons
Centre of gravity of vessel	... 27′ 0″ aft. of amidships
Water over way-ends	7′ 7″
Declivity of keel	·494″ per foot ($\frac{8}{16}$″)
Declivity of ways, mean	·564″ ,, ($\frac{9}{16}$″)
Declivity of ways at start ...	·545″ ,, ($\frac{17}{32}$″)
Camber of ways	21″ in 794′ 0″
Standing ways abaft A.P.	98′ 0″
Standing ways abaft F.P.	64′ 0″
Sliding ways, total length	635′ 0″
Distance apart of ways, centre to centre ...	25′ 0″
Width of ways	6′ 0″
Area of bearing surface	7620 square feet
Mean initial pressure per square ft. of bearing surface	2·20 tons
Maximum pressure on the after end of ways per sq. ft.	about 9 tons
Minimum moment against tipping ...	420,000 feet-tons
Greatest draught aft before lifting ...	33′ 0″
Lifting point from way-ends (statical)...	209′ 0″
Pressure upon fore poppet at lifting point ...	3,700 tons
Pressure upon fore poppet at way-ends ...	1,600 tons
Number of drags on each side	6

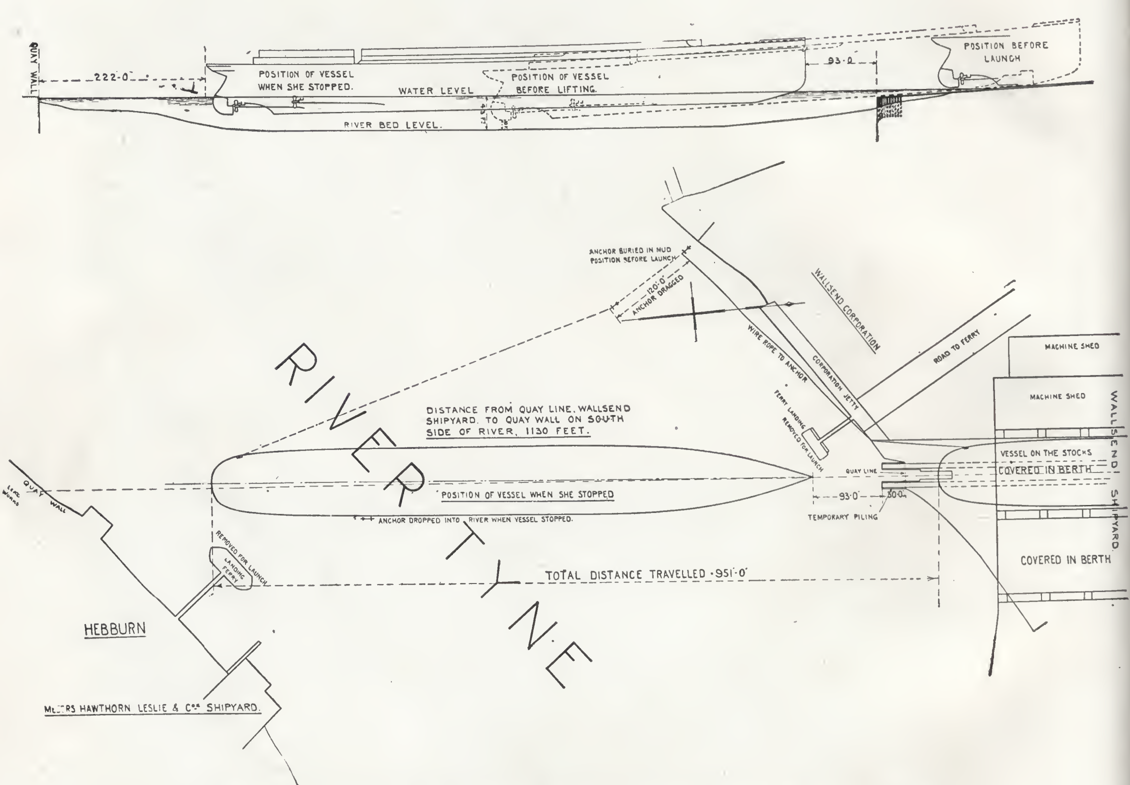


Fig. 45.—Position of Vessel in River immediately after Launch.

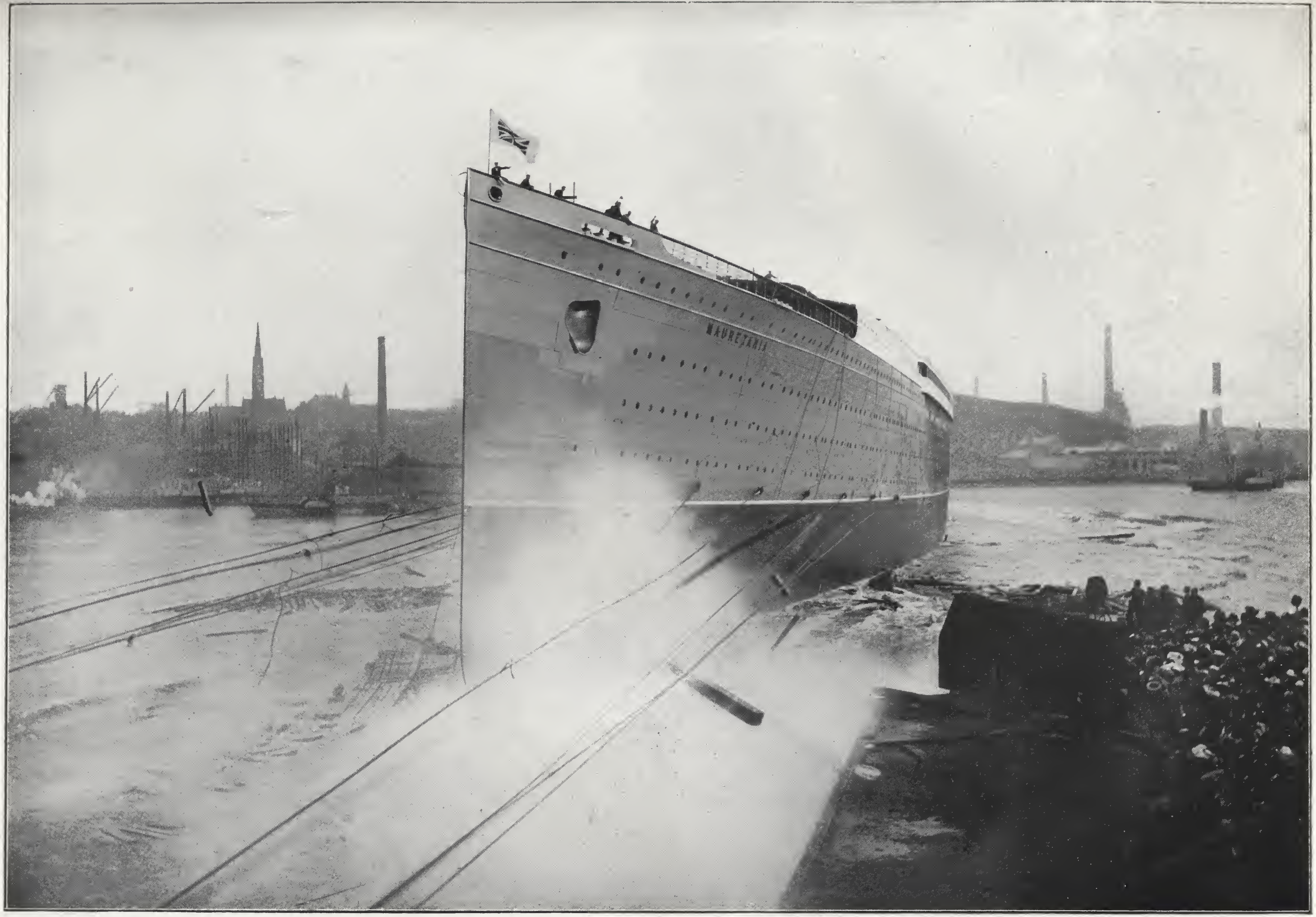


Fig. 46.—Vessel leaving the Ways.

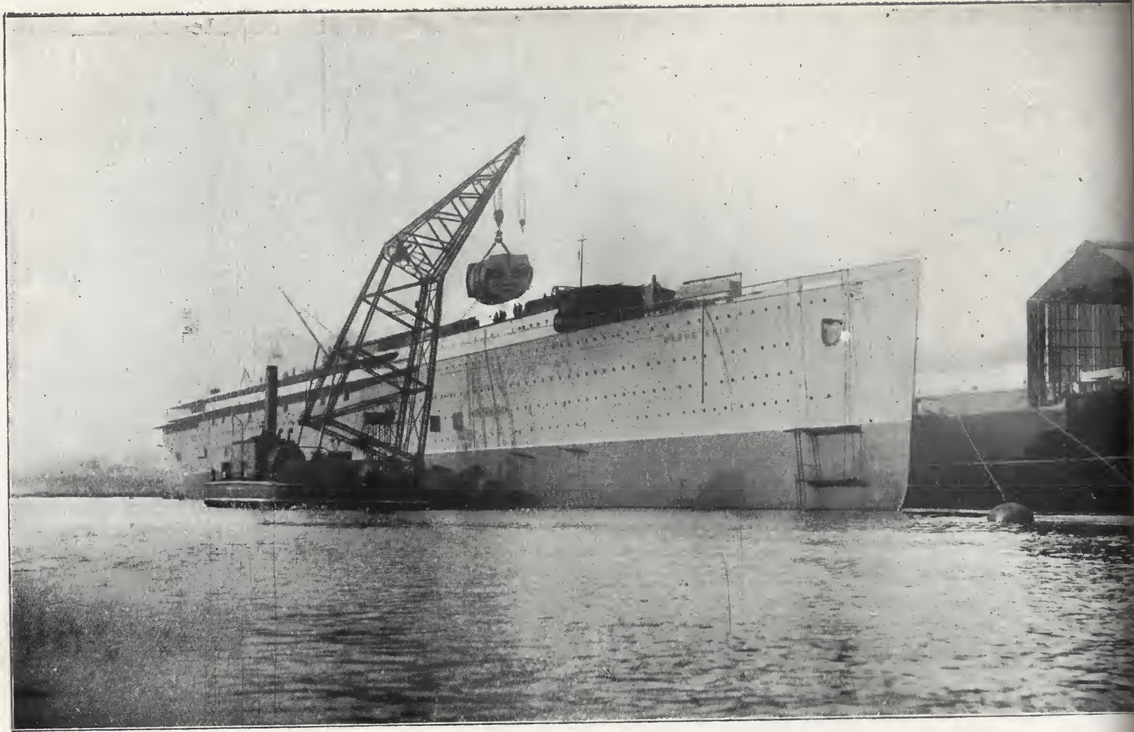


Fig. 47.—Floating Crane putting Boiler on Board.

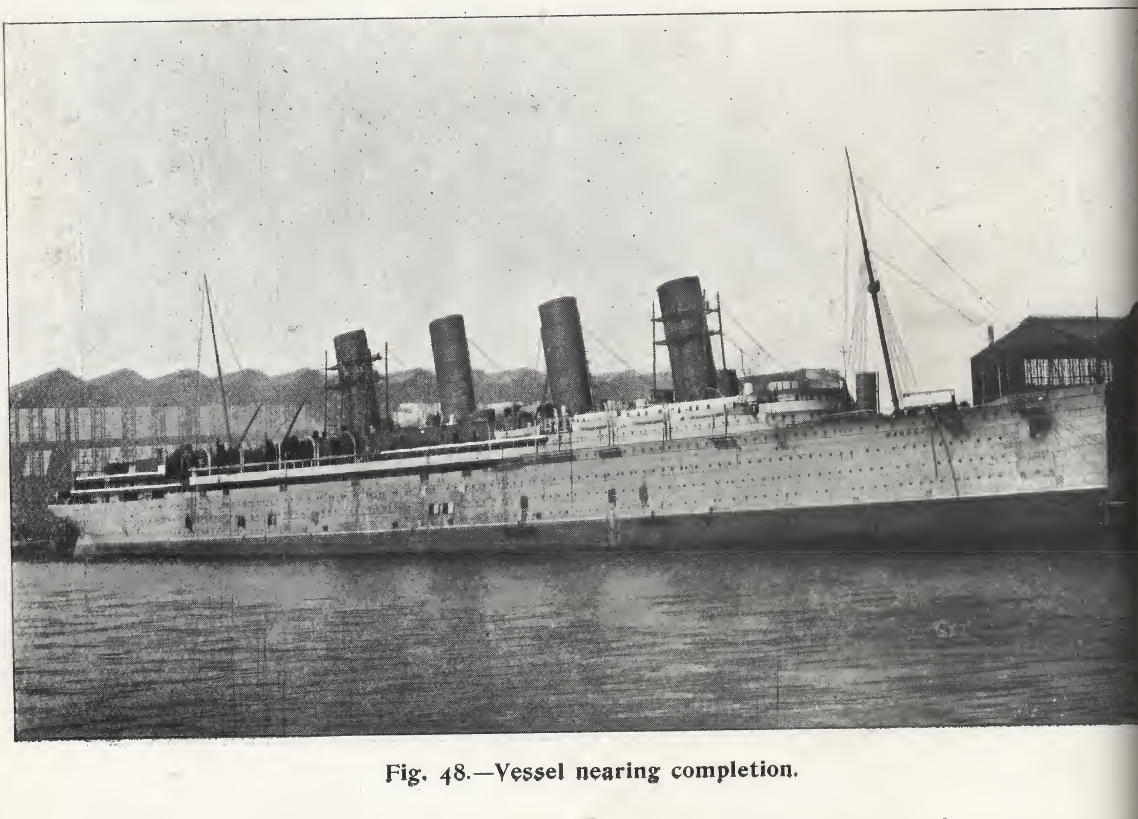


Fig. 48.—Vessel nearing completion.

Total weight of drags	1,015 tons
First drag acted before vessel left ways	33′ 0″
Sixth drag acted after vessel left ways	87′ 0″
Total distance travelled	951′ 0″
Bow of vessel from way-ends when she stopped	93′ 0″
Total time of launch	70 secs.
Time for 6ft. travel from start	7 secs.
Time for 794ft. travel from start	55 secs.
Maximum velocity ... 23·6ft. per sec. = 14 knots per hour	
Maximum velocity was attained after vessel had travelled	480′ 0″
Maximum acceleration	·87ft. per sec.
Maximum acceleration attained after vessel had travelled	150′ 0″

Mean co-efficient of friction for the first 200ft. of travel		·0232
Vertical fall of vessel's centre of gravity from position on the stocks to position when afloat		33′ 6″
Lubricants applied:—		
Tallow, total quantity		$290\frac{1}{2}$ cwts.
Train oil ,, ,,	113 galls =	$12\frac{1}{2}$,,
Soft Soap ,, ,,		22 ,,
Total greased area of ground and sliding ways		17,150 square feet
Lubricant per 100 square feet greased area:—		
Tallow		190 lbs.
Train oil		8 ,,
Soft Soap		$14\frac{1}{2}$,,

Fig. 49.—Bird's Eye View of Vessel.

Fig. 50.—Bridge Front.

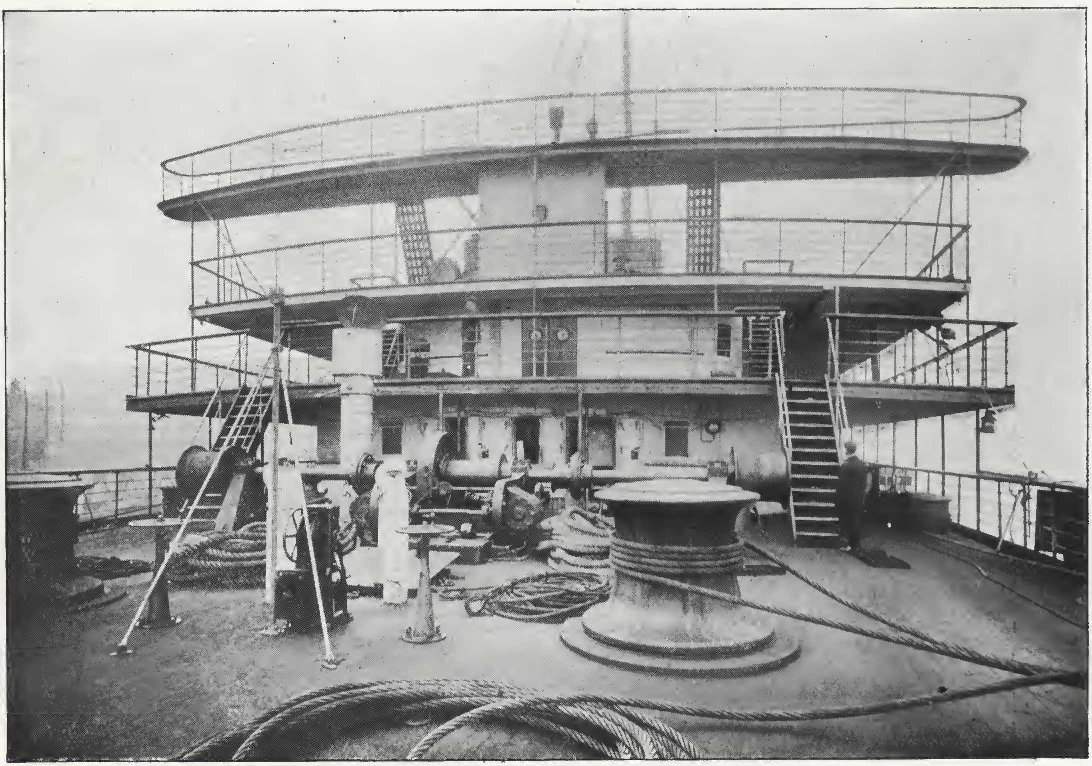


Fig. 51.—View showing after Docking Bridge, &c.

We also reproduce Fig. 40 giving the launching curves; Fig. 41 showing the vessel on the stocks, with the position of the launching triggers and of the drags both before and after the launch; Figs. 42 and 43 showing the forward and after cradles; Fig. 44 showing sections through the cradles, etc.; and Fig. 45 showing the position of the vessel in the river immediately after the launch. An excellent photograph of the vessel just leaving the ways is shown in Fig. 46. Immediately after launching the vessel was taken in tow by six tugs and quickly brought into the position arranged for her opposite the builders' yard (see Fig. 16), where special dredging had been done and two large dolphins constructed for mooring purposes.

* * * *

Completion of the Vessel.

THE completion of the vessel has been accomplished in little more than a year after the launch—a fact which, considering the enormous amount of detail and decorative and other work to be done, reflects credit upon the capabilities and resources of the Wallsend establishment. Shortly after the launch, a commencement was made with the work of putting the machinery on board. The whole of this work was accomplished by the floating crane already referred to, and which may be seen putting a boiler on board in Fig. 47. By the end of 1906 all the boilers were on board, and the erection of the remaining machinery and turbines was begun, the installation being finally placed on board about May, 1907. In Fig. 48 the vessel is seen to have reached a somewhat more advanced stage than depicted in Fig. 47. Our next illustration (Fig. 49) is a very interesting photograph (taken from the roof of one of the building sheds) looking down upon the vessel when nearly complete. She lay over 100ft. from the quay, access to her being gained by a large gangway specially constructed for the purpose. The two special mooring dolphins, to which reference has already been made, are clearly shown in this photograph. Other illustrations represent the bridge front (Fig. 50), and the after docking bridge, etc. (Fig. 51).

On the 17th September, 1907, the vessel left the Tyne on a preliminary trial, which lasted until the 21st, the results giving every indication that she would prove satisfactory in all respects. She then returned to the builders' yard for the finishing touches, and finally left the Tyne for Liverpool on the 22nd October, to be dry docked in Liverpool, before commencing her official trials. An account of the trip to Liverpool and of the official trials will be found elsewhere in the present issue.

The Engine Builders.

THE turbines and boilers of the *Mauretania* have been constructed by the Wallsend Slipway & Engineering Co., Limited, in which concern the shipbuilders are largely interested, the engine works being situated in close proximity to the shipyard where the hull was constructed. The Wallsend Slipway Company was founded in 1873 by the late Mr. Charles Mitchell, with the late Mr. Charles S. Swan as the first managing director. To Mr. William Boyd, who acted as managing director for many years and who is still a director of the company, belongs much of the credit for having built up the marine engineering industry at Wallsend during his long connection with the works, there laying the foundation of an establishment which has carried out many important contracts.

During the last few years the works of the Wallsend Slipway Company have been largely extended and developed, under the direction of

Mr. Andrew Laing.

Mr. William Boyd.

Mr. Andrew Laing, formerly of Fairfield, and during the last ten years the general manager and latterly a director of the Wallsend company. Mr. Laing's past record in the engining of vessels for the Cunard and other steamship lines is so well known that it is perhaps only necessary to say here that his experience in the building of machinery for large mail steamers and war vessels is unsurpassed.

The design and fulfilment of the contract for the propelling machinery of the *Mauretania* has been controlled by Mr. Laing, while the valuable experience of the Parsons Marine Steam Turbine Company, of Wallsend, and Mr. James Bain, general superintendent of the Cunard Company, has been placed throughout at the disposal of the engine builders.

In order to enable them to effectively cope with the very special work connected with the turbine machinery, the engine builders largely re-modelled and added to their works, greatly

Fig. 52.—Wing of Boiler Shop, looking North.

extending the boiler and erecting shops and providing new machinery of the most powerful type. The new wing of the boiler shop (see Fig. 52) is 335 feet long, 75 feet wide, and 60 feet high under the roof, with overhead cranes having a capacity up to 100 tons. The erecting shop, where the turbines have been constructed, is 640 feet long, 60 feet wide, and 51 feet high under the roof and 64 feet to the ridge of the roof, with cranes capable of dealing singly with weights up to 65 tons.

The largest new tool laid down was the immense lathe supplied by Messrs. Armstrong, Whitworth & Company, capable of dealing with the low-pressure turbine rotors 16ft. 6in. diameter and 50ft. long. The height of centres required for this purpose was 108 inches; but in order to make the machine applicable to less exceptional work, an arrangement of packing pieces has been introduced so that the height of centres can be reduced to 60 inches. The lathe is worked by an 80 h.p. motor, and weighs 280 tons.

Reference to the engine builders should not be closed without mentioning the excellent work done by their outside manager, Mr. G. Campbell, and also by Mr. T. McPherson, who has been the assistant to Mr. Laing in the preparation of the details connected with the construction of the propelling machinery.

The Propelling Machinery.

THE machinery has been constructed by the Wallsend Slipway & Engineering Company, Limited, of Wallsend-on-Tyne, and (with the exception of the sister vessel) exceeds by 75 per cent. the greatest power installation previously fitted on board ship. More interesting than the great size, however, is the fact that turbines of the latest Parsons design have been adopted. As already stated, this decision was arrived at after the question had been fully considered by a commission of experts. We now know that the engines have fulfilled every expectation, and it is a fitting tribute to the genius of Mr. Parsons that the giant *Mauretania* should have been constructed in close proximity to the spot where his initial work with the little *Turbinia* was accomplished. In Fig. 53 we give an interesting photograph of the latter vessel alongside the Cunarder.

* * * *

Arrangement of Machinery.

As will be seen from the general arrangement plans of the engine and boiler rooms (Plates VII., VIII. and IX.), the space below the lower deck for nearly the full length of the vessel is occupied by machinery. The Admiralty requirement that all vital parts should be below the load water-line, however, greatly reduced the space at the disposal of the designers, and great ingenuity has been exercised in arranging the different parts to occupy the minimum of space. The boiler installation, which is divided into four groups, each in a separate watertight compartment, occupies a total length of nearly 340 feet, while the length of 260 feet from the stern to the forward engine room bulkhead is occupied almost entirely by the engines and auxiliary machinery. Auxiliary feed, ash ejectors, ballast and refrigerating pumps are arranged in the boiler rooms, as shown on the plan. Above the boilers at the level of the lower deck are placed the fan rooms containing the forced draught fans.

As already mentioned, the vessel has four screws driven by four lines of shafting, each shaft transmitting approximately the same power. The main engines consist of two high-pressure ahead turbines driving the wing shafts, and two low-pressure ahead turbines and two astern turbines connected to the two centre shafts. To ensure the necessary watertight sub-division according to the Admiralty and Bulkhead Committee's requirements, the engine room has been divided into nine separate watertight compartments. The two low-pressure turbines and astern turbines are placed in a central compartment, while compartments at each side of the low-pressure engine room contain the high-pressure turbines. The main feed pumps are arranged on the forward engine room bulkhead, one set being placed in each high-pressure turbine room and two sets in the low-pressure turbine room. A set of evaporator machinery is fitted at the forward end of each high-pressure turbine room, while aft of this the fresh and condensed water pumps are placed in the port room and a refrigerating pump in the starboard room. In the low-pressure room are also fitted the hotwell, bilge, oil, water service, fire and sanitary pumps. In compartments aft of the high-pressure turbine rooms are placed the auxiliary condensers with their air and circulating pumps, the surface heaters, and the main and auxiliary feed filters, while in the port room are also the Stone-Lloyd pumps for operating the watertight doors. The two main condensers are situated in a room extending right across the ship aft of the low-pressure turbine room.

Aft of the main condenser room, and separated by a central longitudinal bulkhead, are the two auxiliary machinery rooms containing the main circulating pumps and the wet and dry air pumps. The installations in each room are identical; so that in the event of one compartment being flooded through collision or other causes, a complete set of auxiliaries is still available in the other compartment. The electric supply station is situated upon a flat at the level of the orlop deck in the auxiliary machinery rooms, and comprises four turbo-generators, two in each room. The remaining watertight compartment devoted to the engines

Fig. 53.—The "Turbinia" alongside the "Mauretania."

is occupied by the tunnels of the two centre shafts. No tunnels are required for the wing shafts, as these leave the ship immediately behind the after bulkhead of the auxiliary machinery rooms.

Boilers. ALTOGETHER there are 23 double-ended and 2 single-ended boilers, the collective fire grate area being about 4,060 square feet and the heating surface about 159,000 square feet, with a working

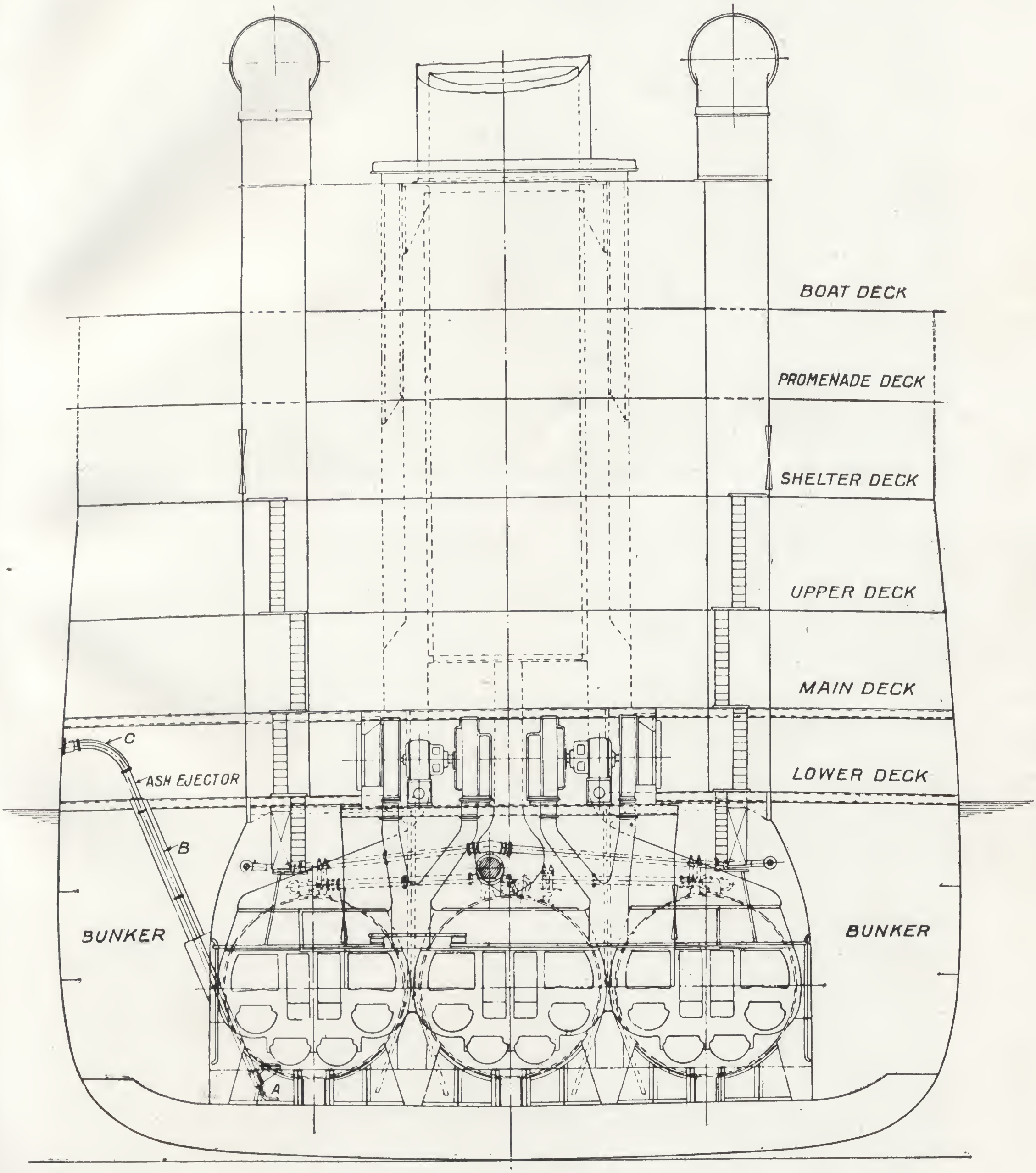


Fig. 54.—Section through Boiler Room.

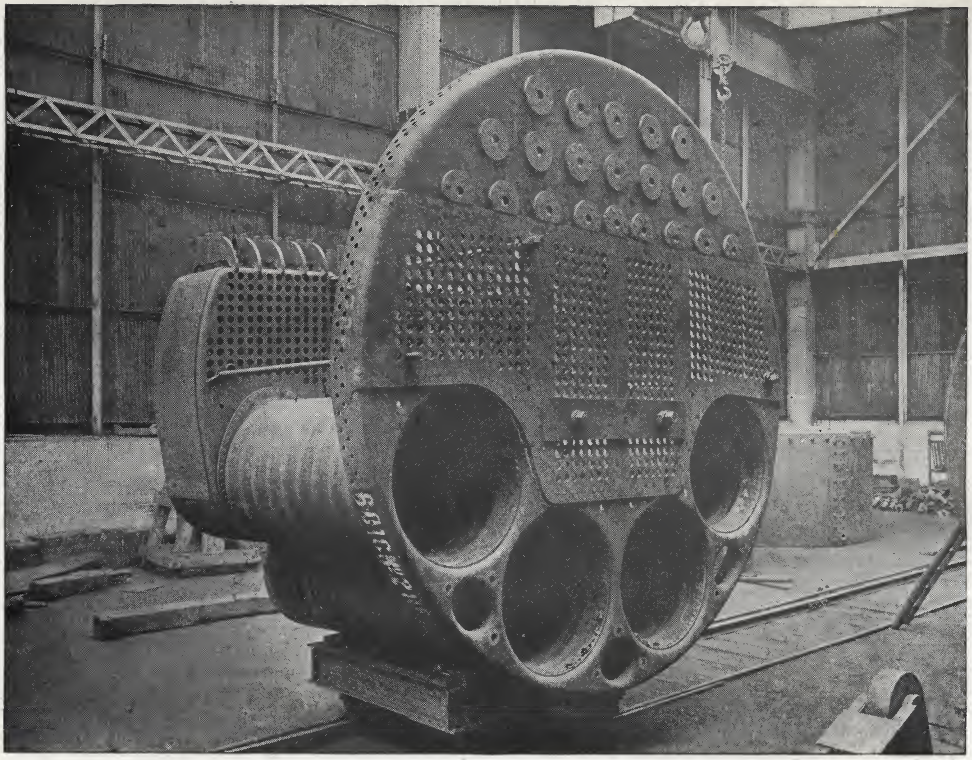


Fig. 55.—Boiler Front with Furnaces and Cumbustion Chamber.

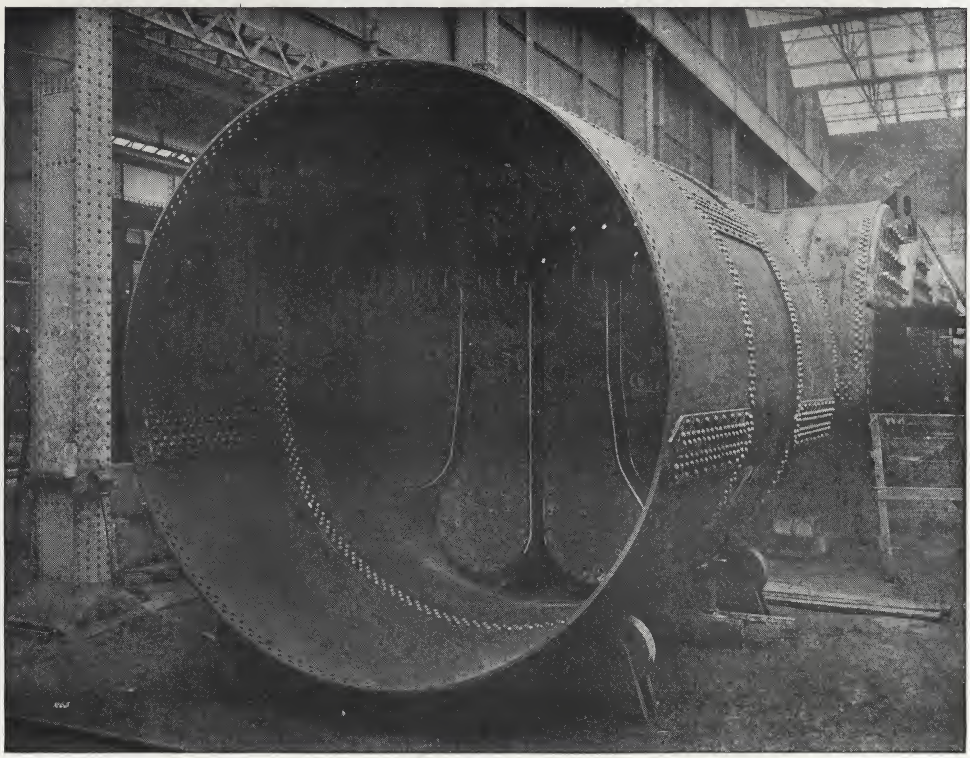


Fig. 56.—Boiler Shell with one set of Combustion Chambers.

pressure of 195lbs. per square inch. The foremost, or No. 1 boiler room, contains 5 double-ended and 2 single-ended boilers, while the other three compartments, known as Nos. 2, 3 and 4 boiler rooms, each contain 6 double-ended boilers. Each of the double-ended boilers is about 17ft. 3in. diameter and 22ft. long, and contains eight furnaces, as shown on the section of Fig. 54; while the single-ended boilers, which are of the same diameter as the double-ended but are 12ft. long, contain four furnaces; so that the total number of furnaces is 192. The latter are of the Morison suspension type and were made by the Leeds Forge Co. Separate combustion chambers are fitted to each furnace. The internal construction of the boilers is well illustrated in Figs. 55 and 56. The boiler end plates are of mild steel; but for the shell plates and stays, high-tensile silicon steel of 36 to 40 tons per square inch, made by Messrs. John Spencer and Sons, of Newburn, has been adopted. The boilers have been lagged with Newall's magnesia coverings, supplied by Magnesia Coverings, Limited, Washington, County Durham. A photograph of some of the boilers in course of erection in the boiler shop is given in Fig. 57; and the whole of the boilers, as arranged in the shop for inspection on the day the vessel was launched, are shown in Fig. 58.

The funnels are four in number, one from each boiler room. They have an elliptical cross section and measure 23ft. 7in., by 16ft. 7in., their height being 153ft. above the base line of the ship. On the day of the launch they were placed end to end in the builders' yard and formed a novel tunnel for the passage of motor cars containing a party of guests, as shown in Fig. 59. Other illustrations (Figs. 60 and 61) show the smoke boxes and a set of uptakes for one boiler room, giving some idea of the elaborate arrangement required to convey the waste gases from six boilers into one funnel.

Fig. 57.—Large Bay of Boiler Shop with part of "Mauretania's" Boilers in course of erection.

Fig. 58.—Boilers arranged in Shop for inspection.

Fig. 59.—Motor Cars passing through Funnels.

Fig. 60.—Smoke Boxes.

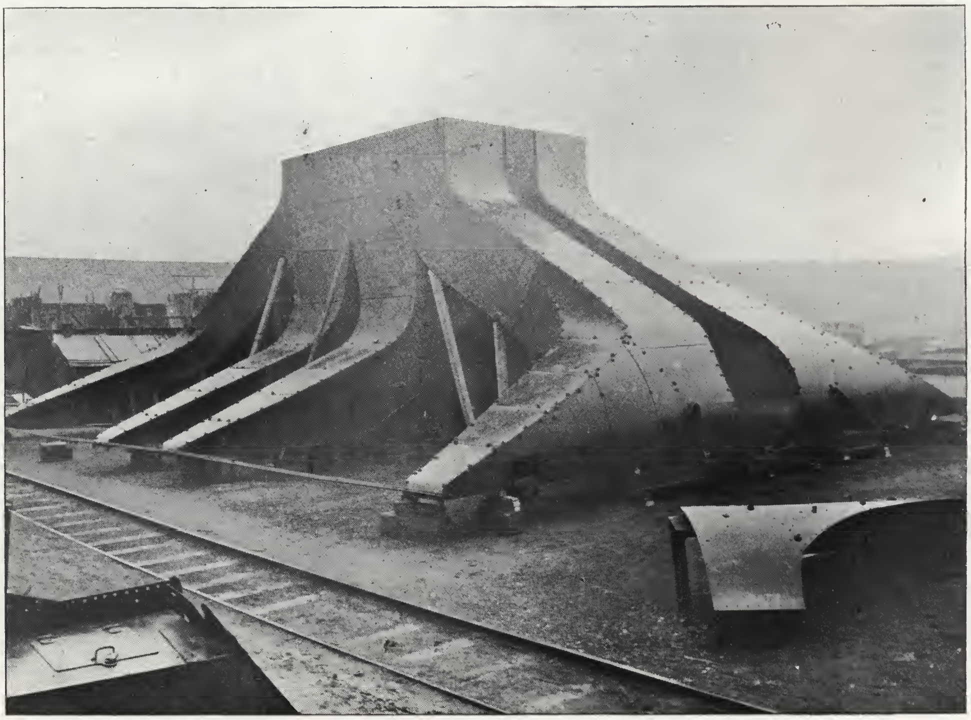


Fig. 61.—Set of Uptakes for one Boiler Room.

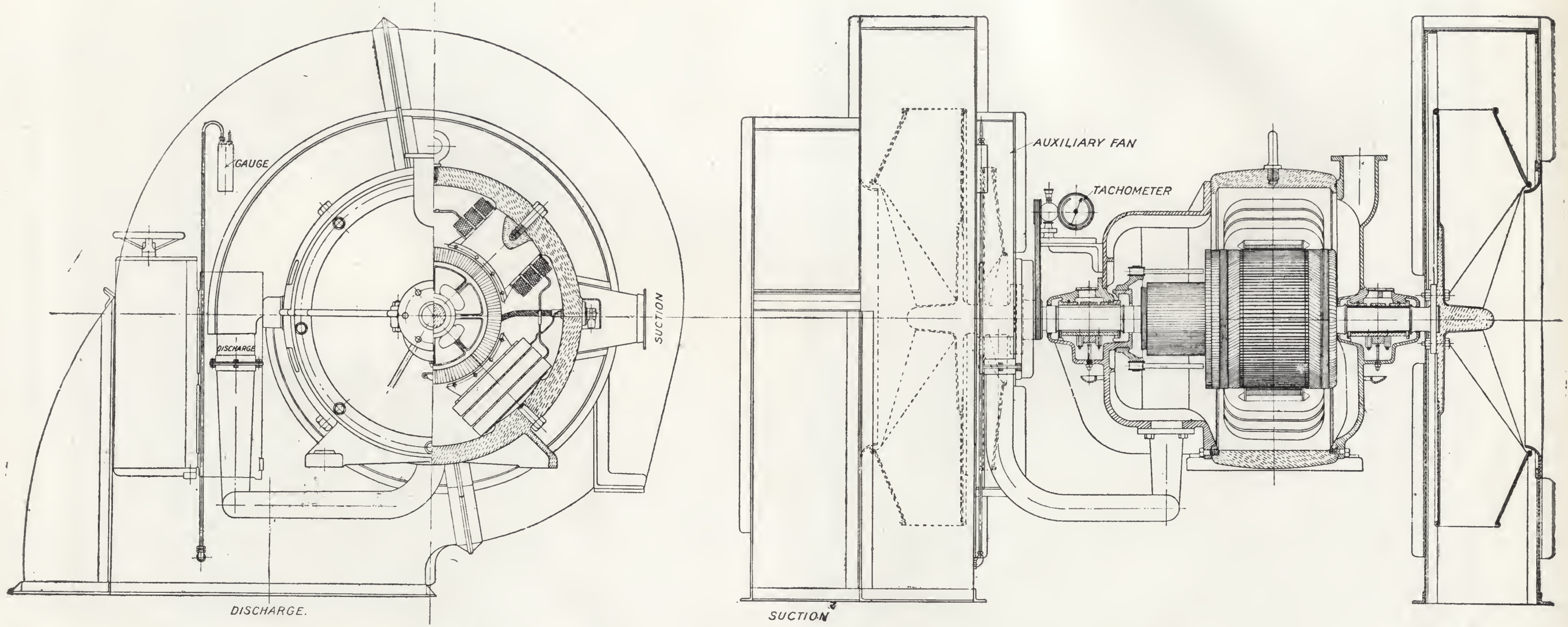


Fig. 62.—Forced Draught Fans.

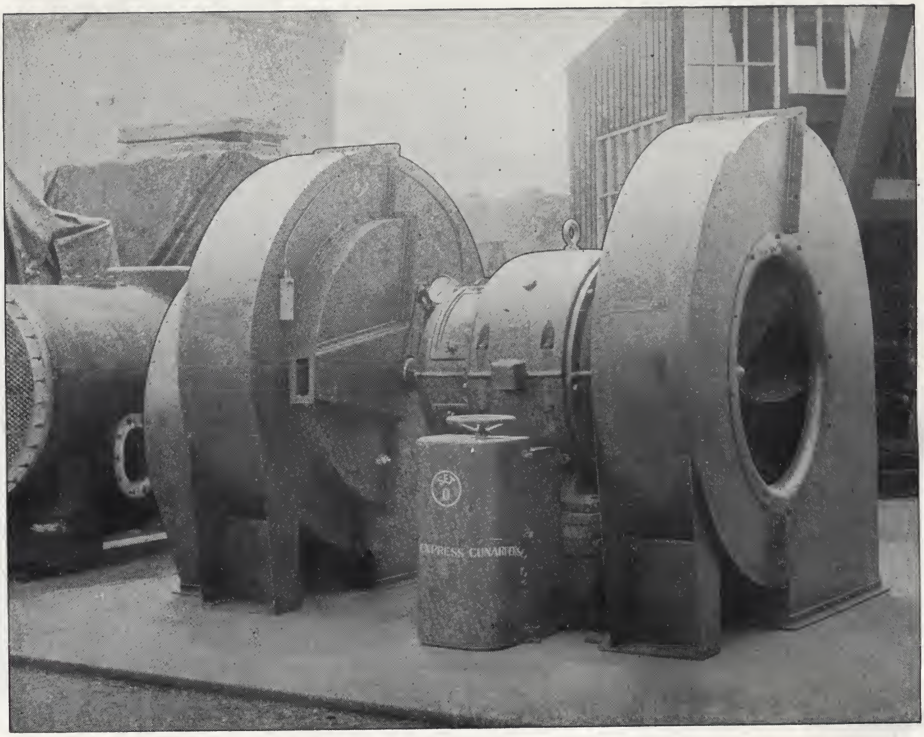


Fig. 63.—Forced Draught Fans.

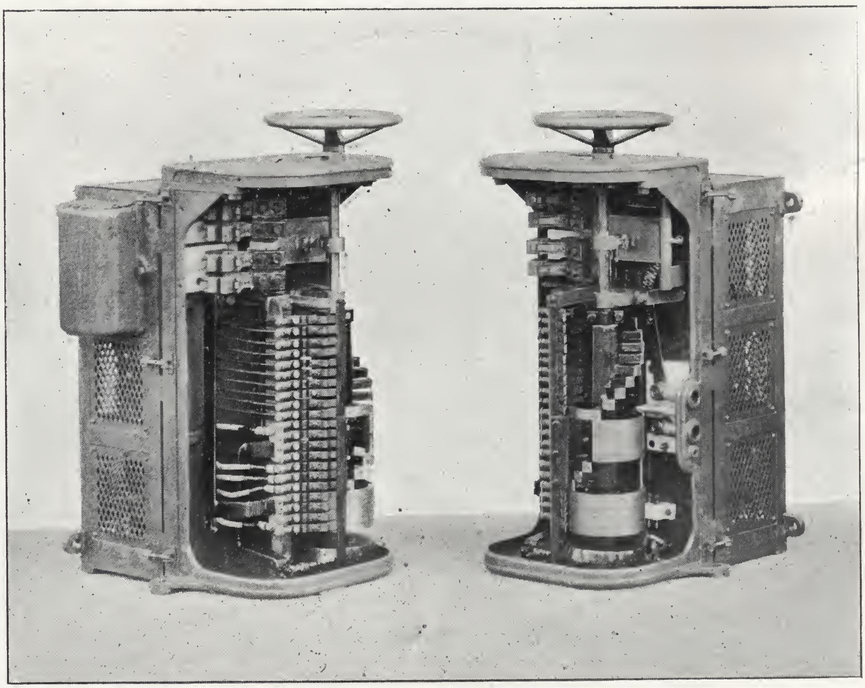


Fig. 64.—Control Gear for Forced Draught Fans.

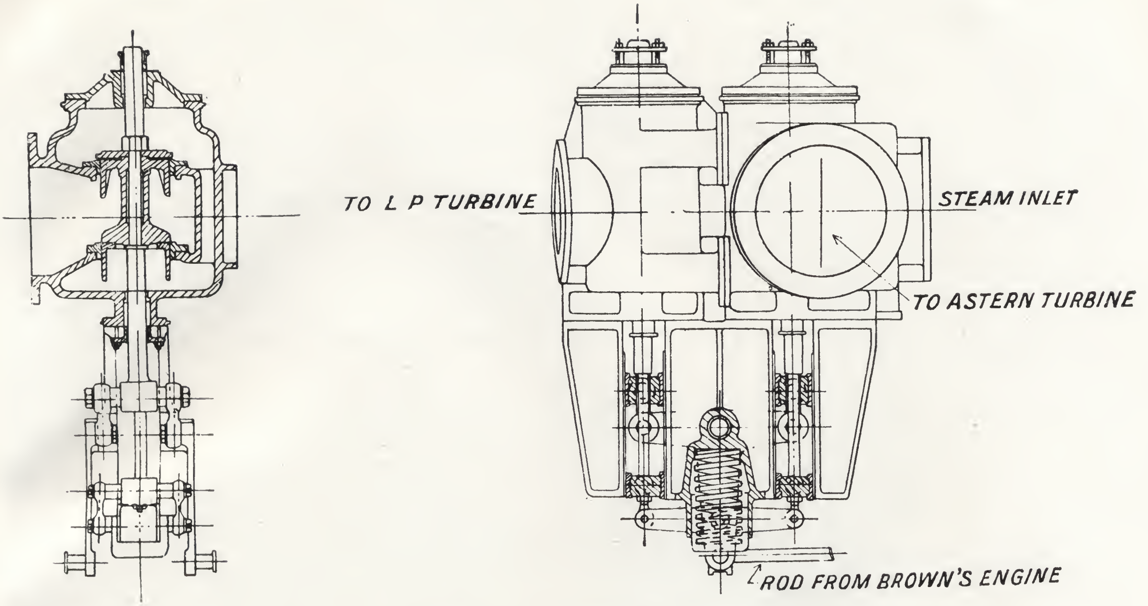


Fig. 65.—Manœuvring Valve.

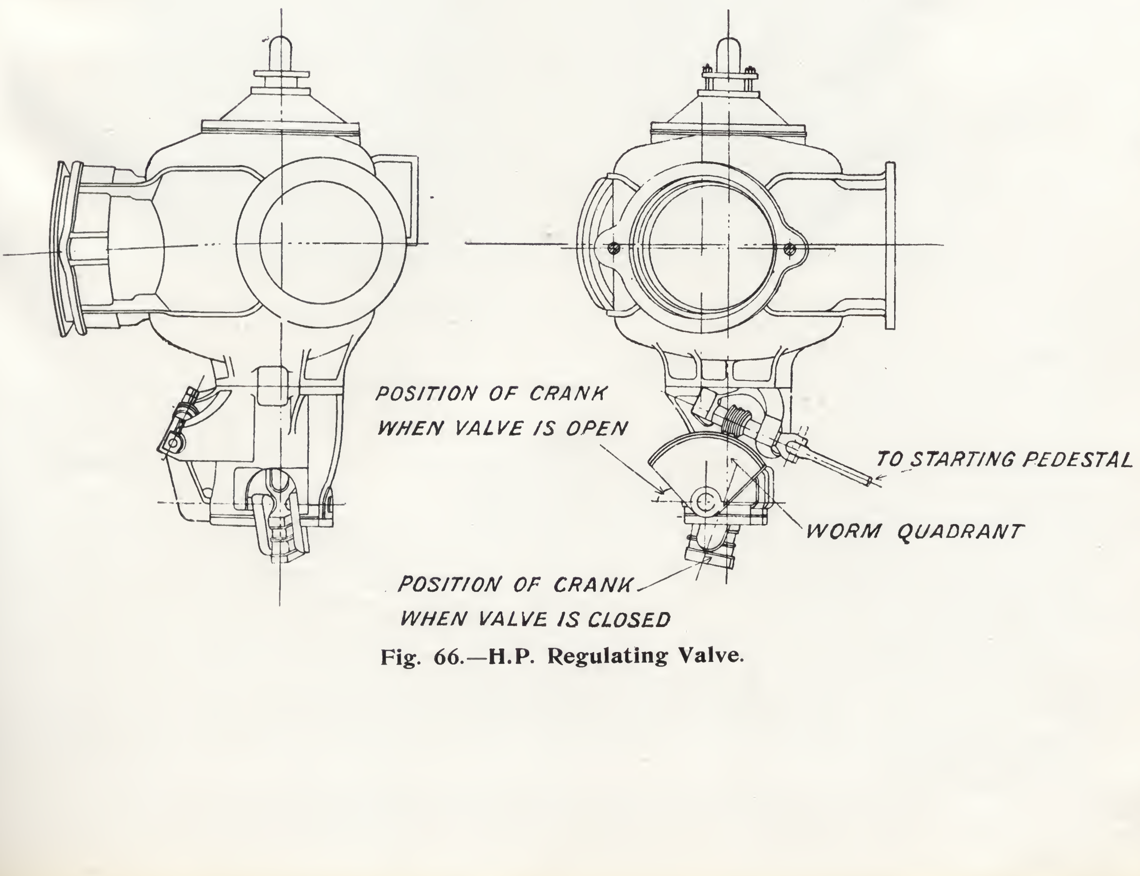


Fig. 66.—H.P. Regulating Valve.

Bunker Arrangements. In order to obtain the best distribution of fuel in relation to the stokeholds, and to avoid the necessity of transporting the coal over long distances when the vessel is on service, continuous side bunkers have been fitted throughout the boiler rooms, with doors in the bunker sides which permit the coal to trim directly on to the stokehold floor. In way of No. 1 boiler room, however, owing to the ship becoming narrower, it was not possible to obtain in the side bunkers a capacity equivalent to that obtained in the other boiler rooms, and a cross bunker has therefore been placed at the forward end of this room to maintain the necessary coal supply. The permanent bunkers have a capacity of about 6,000 tons, and arrangements have been made for carrying reserve coal in No. 2 hold and in the 'tween decks over No. 2 boiler room if required. The continuous bunkers will form valuable side protection to the boiler rooms, and the cross bunker will protect against a raking fire, in the event of the vessel being used as an armed cruiser. The bunkers are filled through shoots in the side of the vessel, including two to each side compartment. The shoots feed into trunks placed between the lower and main decks, the trunks also forming bunker escapes with ladders from below. Hinged doors secured by strong dogs allow access from the trunks into the third-class spaces in the lower 'tween decks.

* * * *

Ash Hoists and Ejectors. The arrangements for discharging ashes consist of eight Crompton's ash hoists, two of which are placed in each double stokehold, and eight See's ash ejectors, one of which is placed in each single stokehold. The ash hoists have been supplied by Messrs. A. Crompton & Co., London, and are of their usual system, known as the silent atmospheric ash hoist. This apparatus consists of a long tube in which works a piston, connection being made to the tube beneath the piston to produce a vacuum. From the top of the piston a rope is led over a pulley, and down a second or guide tube to the ash bucket. When it is desired to lift the ash bucket, a lever is turned which operates the connection for producing the vacuum in the lower portion of the piston chamber, and the piston descends, thereby hoisting the bucket. When raised to the main deck, the bucket is tipped into a shoot, which discharges the ashes through the ship's side. The vacuum is then destroyed in the piston

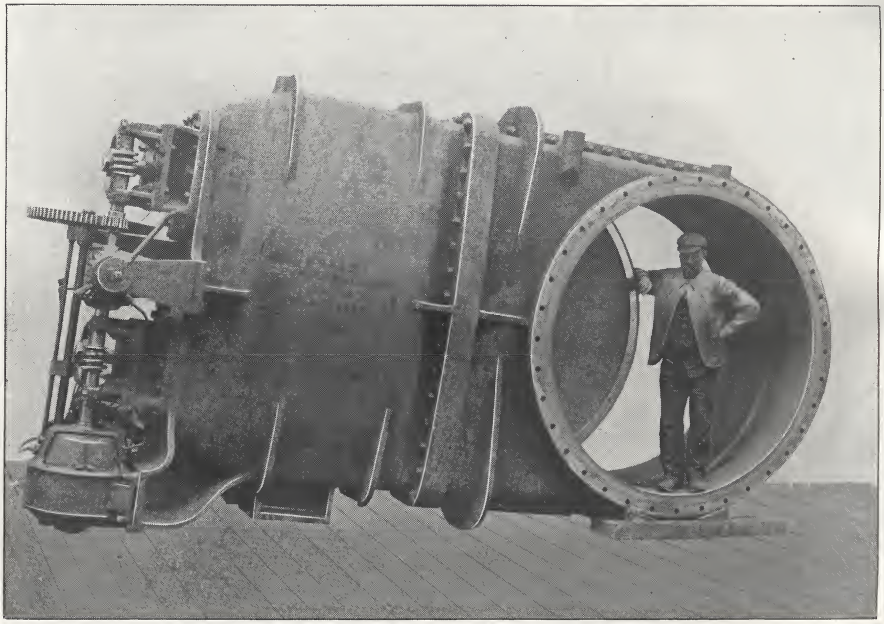


Fig. 67.—75in. Sluice Valve on Exhaust Pipe between H.P. and L.P. Turbines.

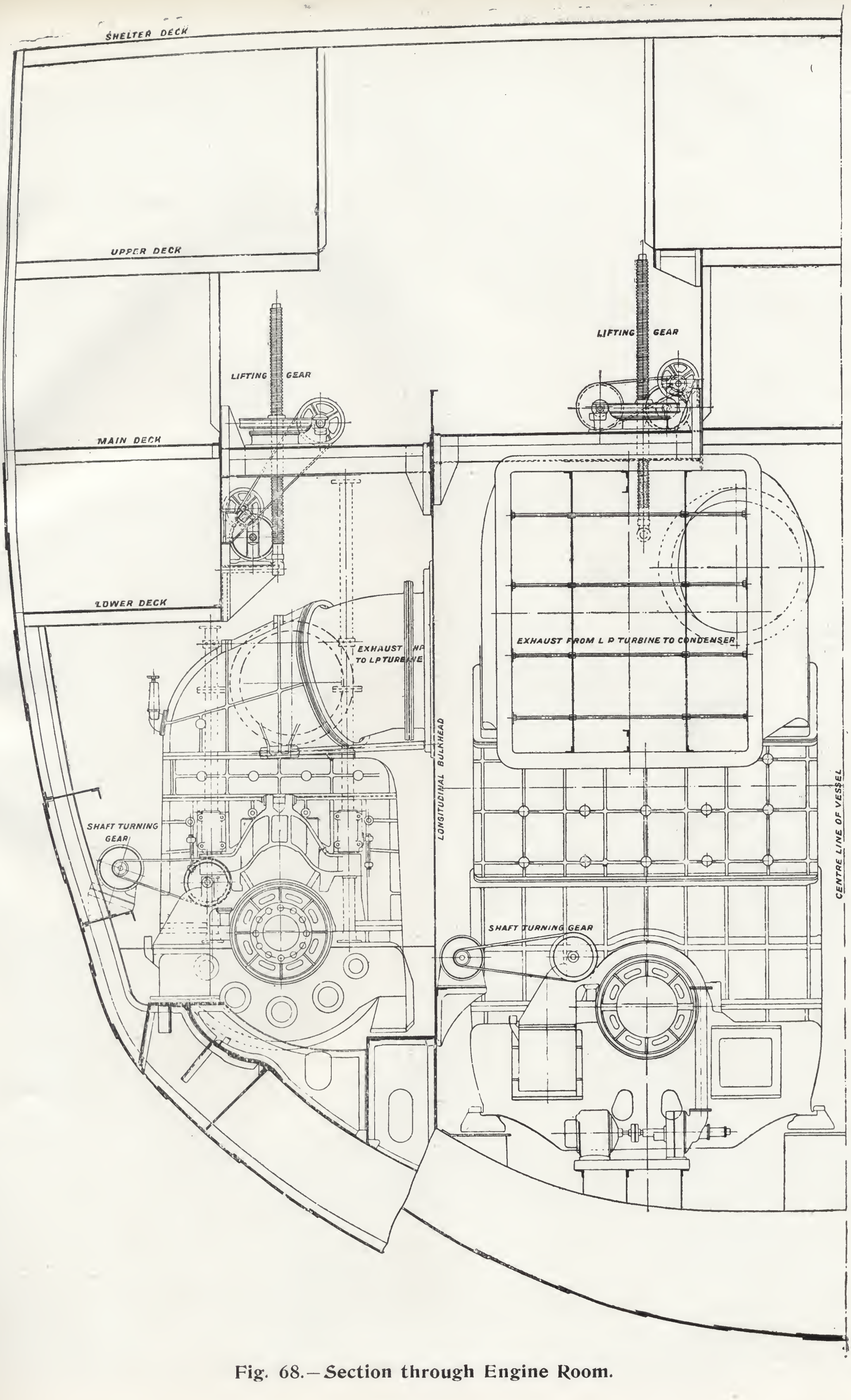


Fig. 68.—Section through Engine Room.

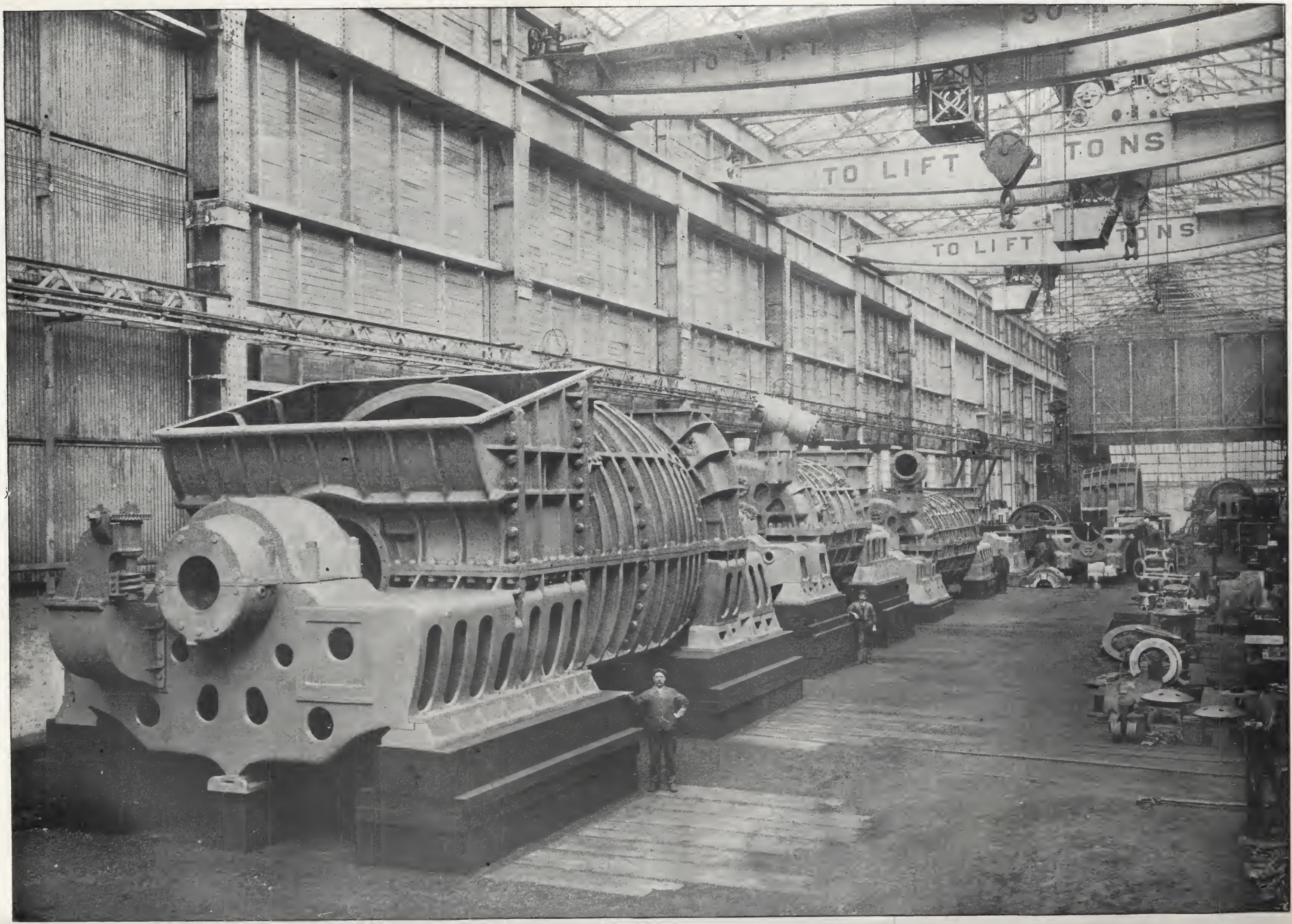


Fig. 69.—One Set of Turbines in Erecting Shop.

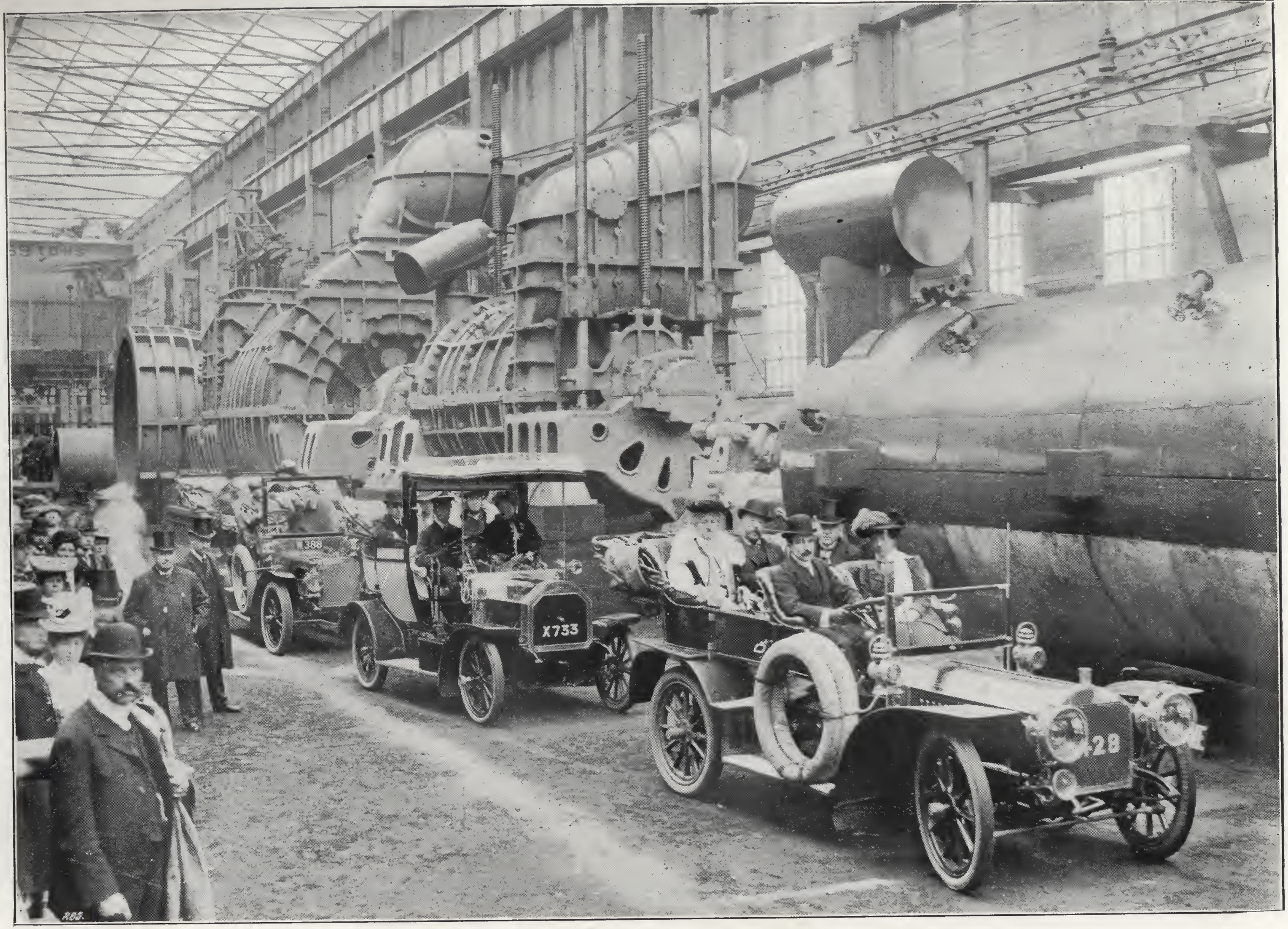


Fig. 70.—Another View of Turbines in Erecting Shop.
(This photograph was taken during the inspection on 20th September, 1906.)

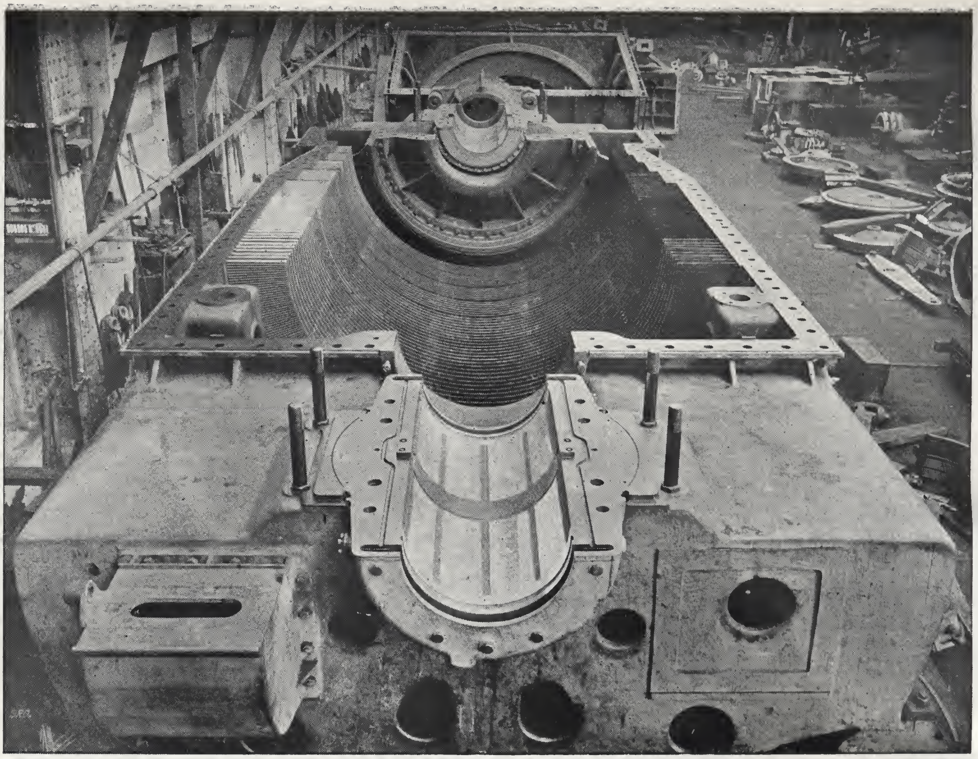


Fig. 71.—Bottom Part of L.P. Turbine Casing.

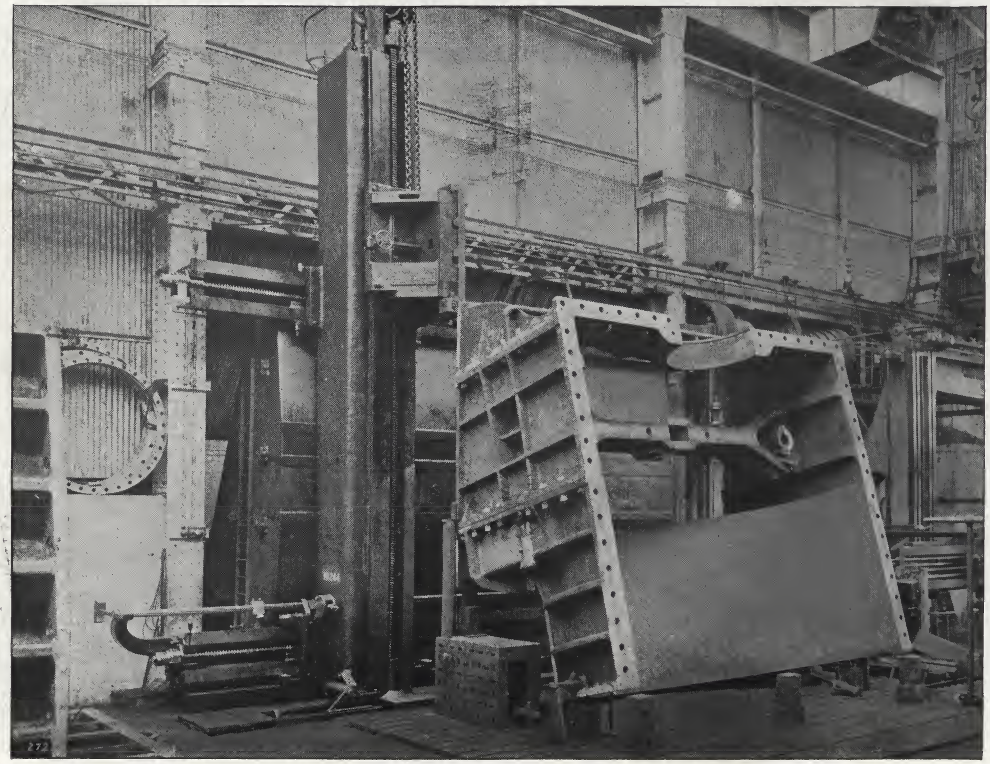


Fig. 72.—Part of Exhaust End of L.P. Turbine in Planer.

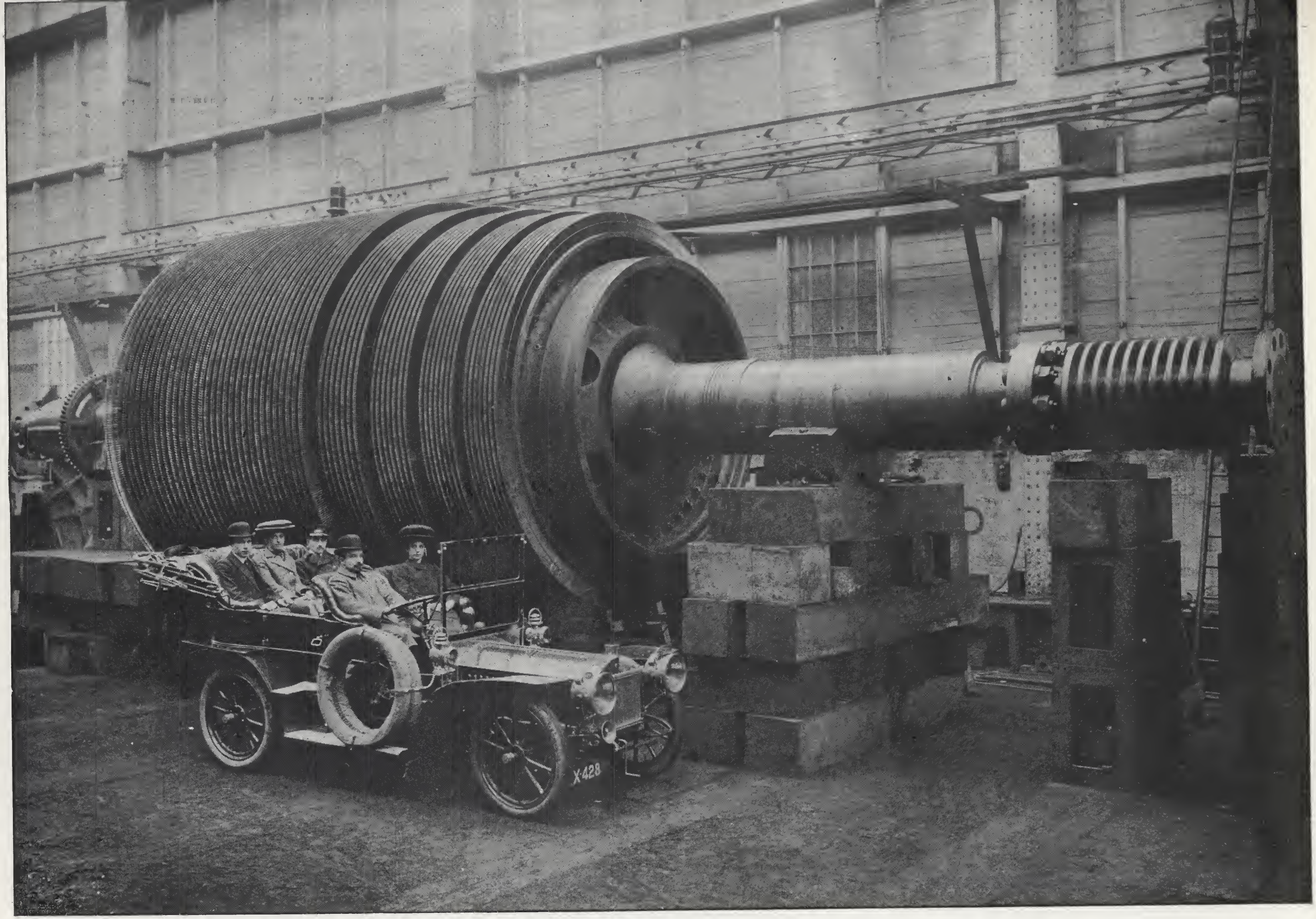


Fig. 73.–L.P. Rotor, fully bladed.

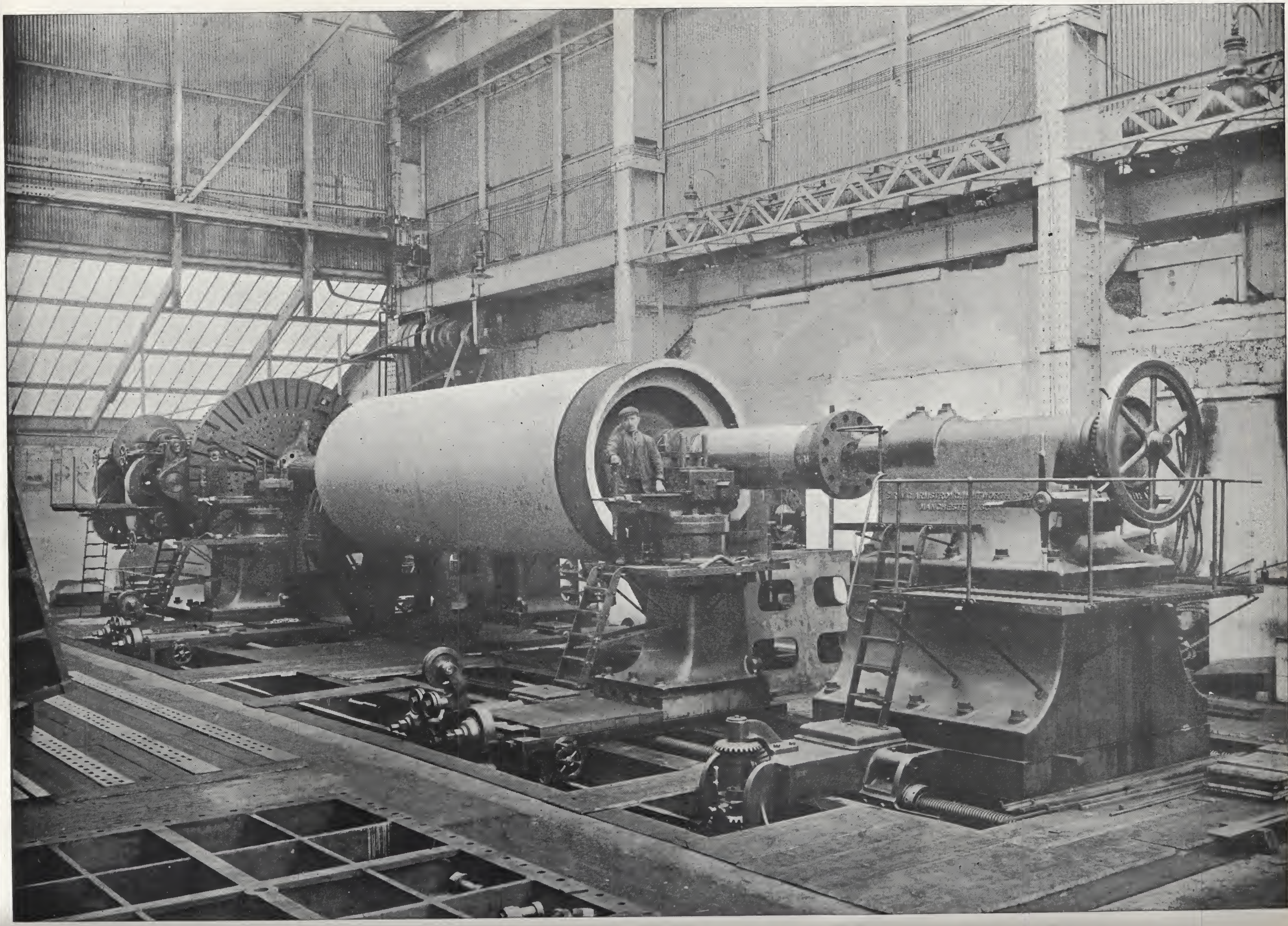


Fig. 74.—H.P. Rotor in large Lathe.

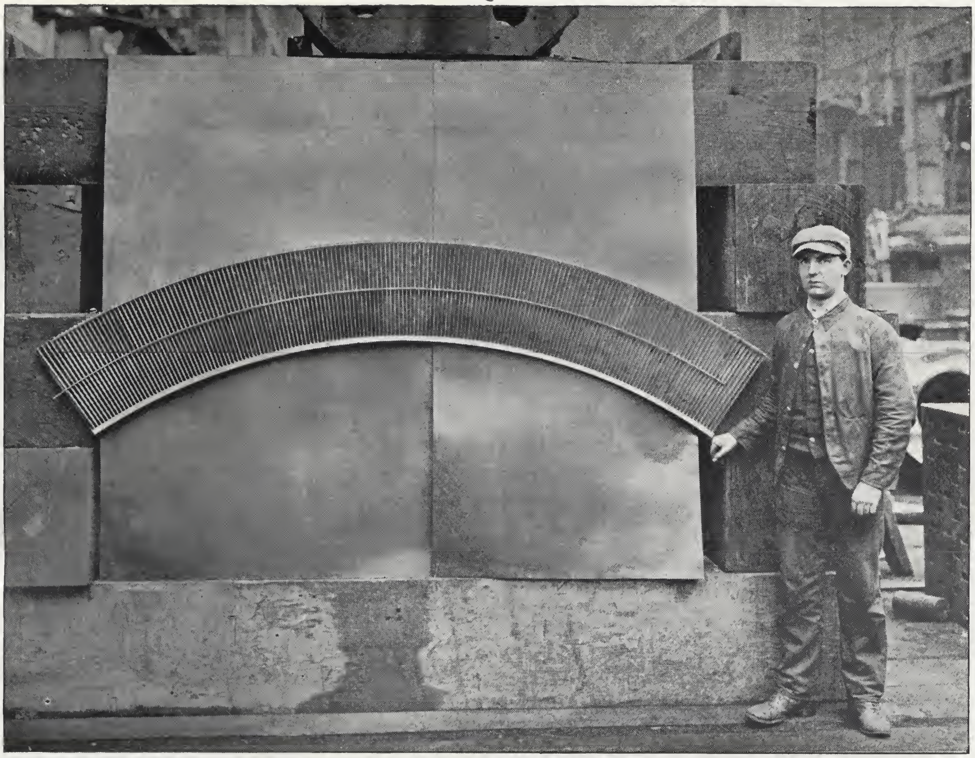


Fig. 75.—Segment of Turbine Blading.

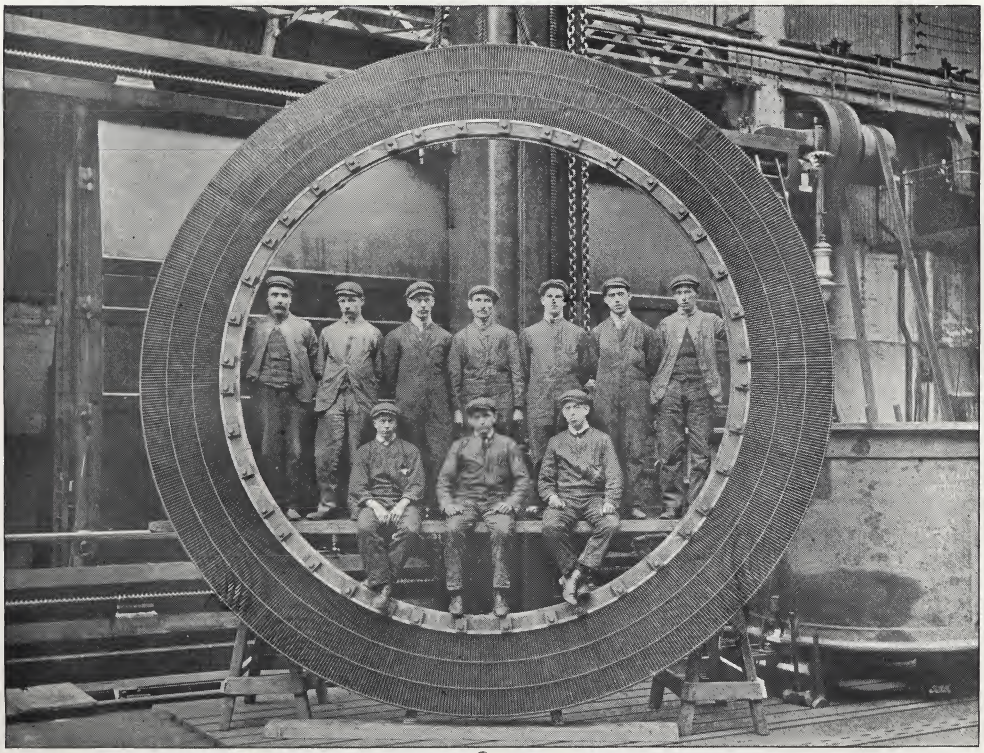


Fig. 76.—Complete Ring of Turbine Blading.

tube and the bucket descends by its own weight.

The arrangement of See's ash ejector is well known and need hardly be described in detail. The position of the ejector is shown in Fig. 54. Briefly, the method of working is as follows:—When the ashes are shovelled into the hopper A, they are drawn down by the rush of air to a water jet which is being discharged through the pipe B at a pressure of about 150lbs., the jet being maintained by the ash ejector pump. The water jet carries the ashes up the tube B, till at the bend C they are deflected and discharged well clear of the ship's side.

* * *

Forced Draught and Fans.

THE boilers are fitted with Howden's system of forced draught, which is maintained by 32 electrically driven fans supplied by Messrs. W. H. Allen, Son & Co. The air supply is obtained through large square ventilating trunks led from the boat deck house top. Six of these trunks are led to each boiler room and are surmounted by cowls of the ordinary type, 6ft. 3in. diameter. They also contain escape ladders from the stokeholds. The air enters the stokeholds at the wings, and by means of screens is induced to pass right across the stoking platform before going to the fan inlets, with the result that the stoking platforms are remarkably cool. The fan rooms, of which there are eight altogether, are situated in the boiler casing at the level of the lower deck, at each end of each boiler room. Each room contains four fans, two of which draw from the centre stokehold and two from the end stokeholds. The fans are arranged in pairs, each pair being driven by one motor. Their construction is well illustrated in Fig. 62 and the photograph given in Fig. 63. The

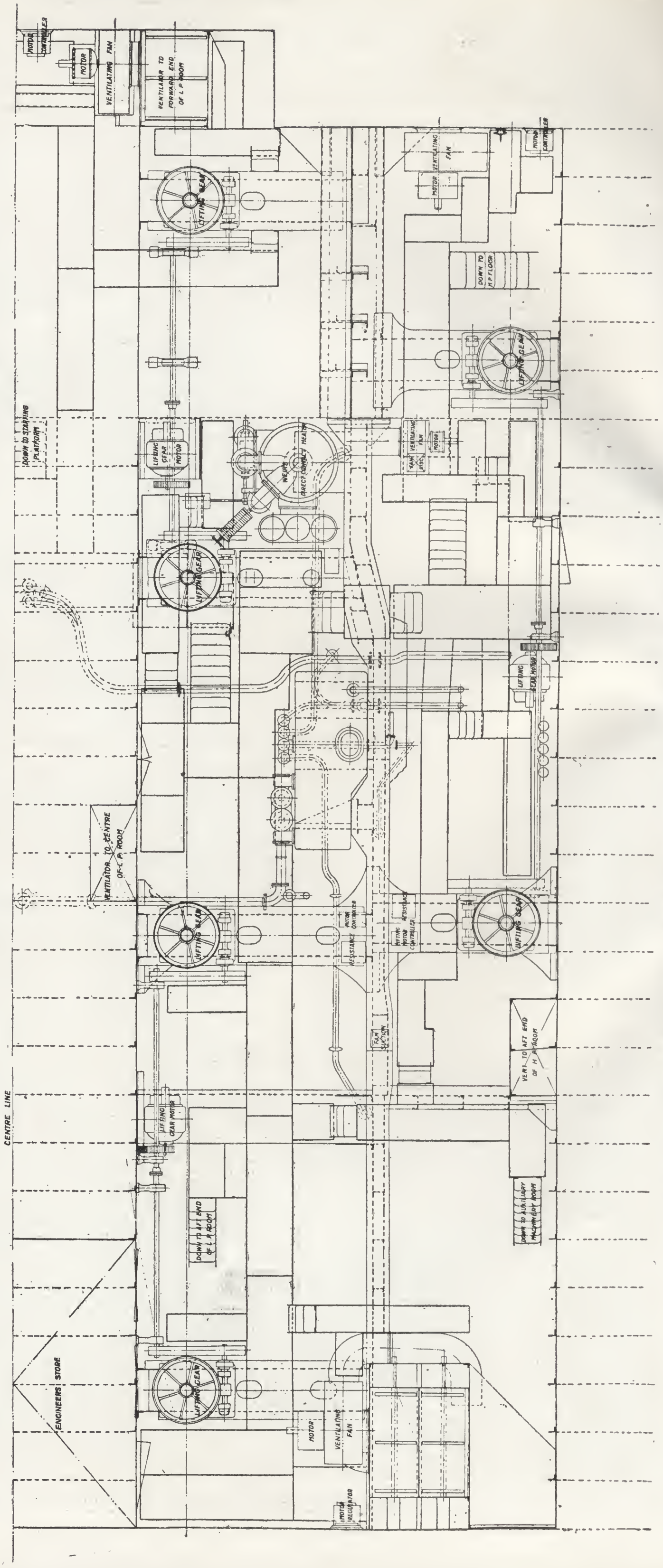


Fig. 77.—Plan of Engine Casing at Main Deck, showing Turbine Lifting Gear.

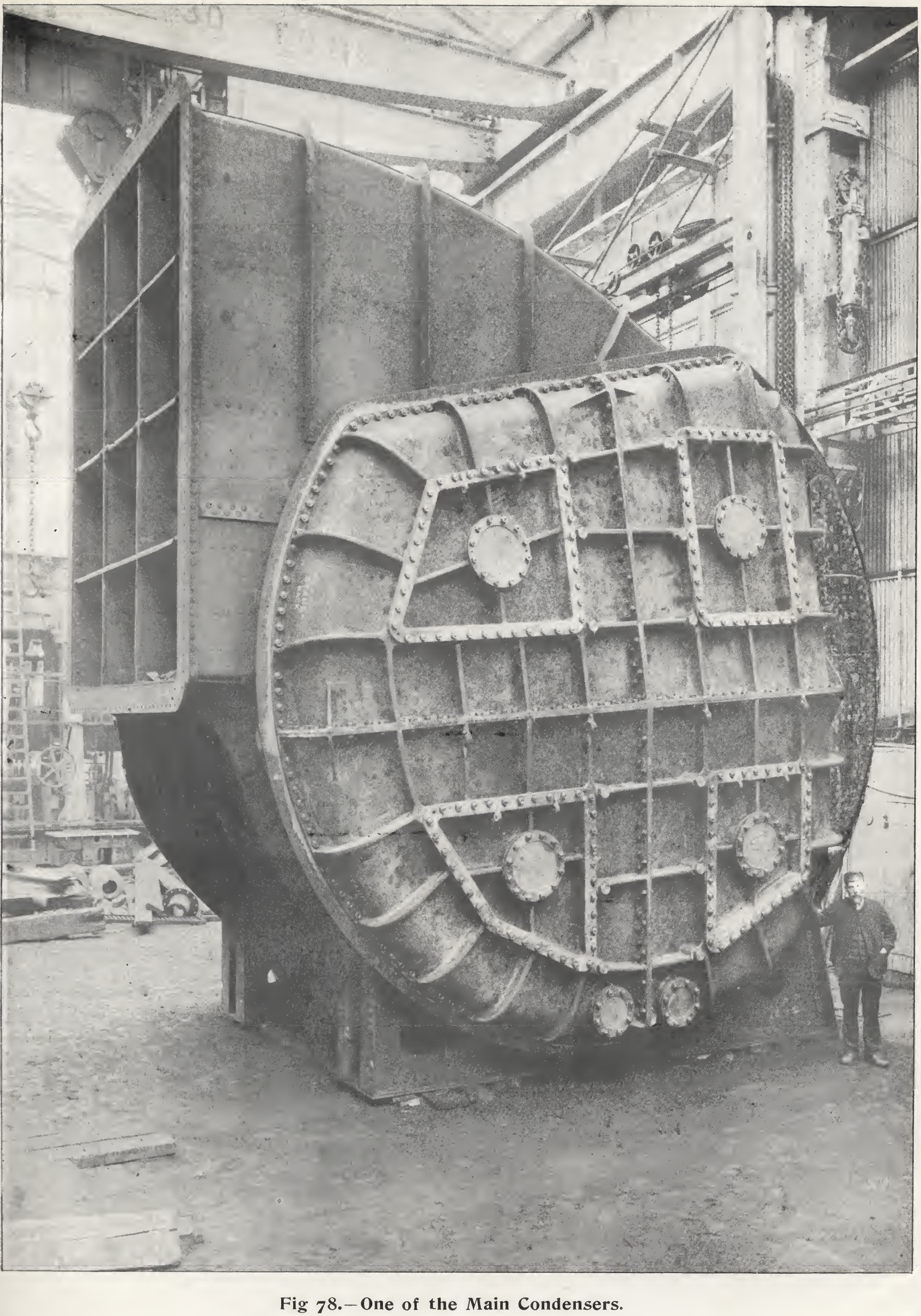


Fig 78.—One of the Main Condensers.

motors are of the four-pole continuous current type completely enclosed, and are each capable of developing 50 B.H.P. at a speed of 450 revolutions per minute, when supplied with current at a pressure of 110 volts. The impellers are of the single-inlet type, 66 inches diameter, and are capable of delivering 33,000 cubic feet of air per minute against a water pressure of $3\frac{1}{2}$ inches on the discharge side when running at 450 revolutions per minute. These impellers are made of brass plate of special composition to resist corrosion, with steel bosses. The output can be regulated by the controllers, which are also of Messrs. Allen's manufacture and are capable of varying the speed between 225 and 450 revolutions per minute. When running at the lowest speed, the approximate output of each fan is about 17,000 cubic feet per minute, against a water pressure of 1 inch. The controllers are illustrated in Fig. 64, and can be worked either from the fan room or the stokehold floor. Each fan room is well ventilated by a separate 21-in. fan of Messrs. Allen's single-inlet type, capable of delivering 1,000 cubic feet of air per minute against a water pressure of 1 inch, when running at a speed of 900 revolutions per minute. The motors for these fans are of the four-pole series wound type, totally enclosed, and each capable of developing normally an output of 5 H.P. when supplied with current at a pressure of 110 volts and running at the maximum speed.

* * * *

Steam and Exhaust Pipes and Valves. THE arrangement of main steam pipes, of which there are two, is shown in Plate VII. The two main stop valves are placed on the forward engine room bulkhead, and are worked by two engines of the Brown type, controlled from the starting platform. The Brown engine is also controlled by an Aspinall's governor, so that in the event of the turbines exceeding their proper speed, the governor acts upon the valve of this engine, immediately shutting off steam. The steam then passes through a large separator for extracting all water before it passes into the turbines. From the separator the steam passes through the manœuvring valve, by means of which the centre shafts may be reversed, the steam being directed either towards the ahead turbines or to the astern turbines. It was necessary that this valve should not be open to both ahead and astern turbines at the same time. As will be seen from Fig. 65, the manœuvring valve really consists of two valves, one admitting

Fig. 79.—Condenser Tube Plate.

steam to the astern turbine and the other admitting steam directly to the L.P. turbine. The ends of both the valve spindles are connected to a lever with a central fulcrum, upon which bears a spring, the other end of the spring bearing against the casting forming the guides. Above this lever is a second lever, also with a central fulcrum, the ends of the latter being attached to link blocks sliding in guides. These blocks slide freely on the valve spindle when moved downwards, but bear against a collar on the spindle if moved upwards. On the lever driving the blocks is an extension to take the connecting rod of the Brown's engine. When the engine moves in one direction, one of the blocks, moving up, engages the spindle and lifts one valve. The other block meanwhile moving downwards rides freely on the spindle, and hence does not affect the other valve. In bringing the Brown's engine back into mid-position again, the sliding block leaves the spindle of the valve which is open, and the spring brings the valve back. Before going to the high-pressure turbine, the steam passes through the high-pressure regulating valve, which is illustrated in Fig. 66 and which can be worked either from the high-pressure room or from the starting platform. As will be seen from Fig. 66, the gear for this valve is of a very powerful type. The lower end of the valve spindle is fitted with a crosshead which takes the top end of a connecting rod, the lower end of which embraces the crank. Keyed to the crank shaft is a worm quadrant, the worm shaft of which is led to the starting pedestal in the L.P. room. An auxiliary hand gear is also fitted in the H.P. room for working the same shaft. The gear is arranged so that the crank is almost on the lower dead centre when the valve is closed, thus applying a very powerful closing force.

The starting platform is situated in the low-pressure room at the forward end of the astern turbines, at the level of the engine room floor, the position being remarkable for its coolness. From this starting platform the whole of the machinery can be controlled. The starting arrangement for each of the two sets of turbines is mounted upon a separate pedestal at the side of the centre passage. Each set of starting gear consists of a large hand wheel controlling the admission of steam at the bulkhead stop valves, with an inner wheel controlling the manœuvring valve, while the steam pressure gauges, telegraph dials and revolution counters are mounted on the same pedestal. Immediately to the right of each pedestal are situated the levers for controlling the turbine drain and sluice valves.

From the high-pressure turbine the steam exhausts either to the low-pressure turbine or by a separate connection directly into the condensers. The sluice valves upon these connections are of remarkable size, being 75 inches diameter upon the connection between the high and low-pressure turbines, and 60

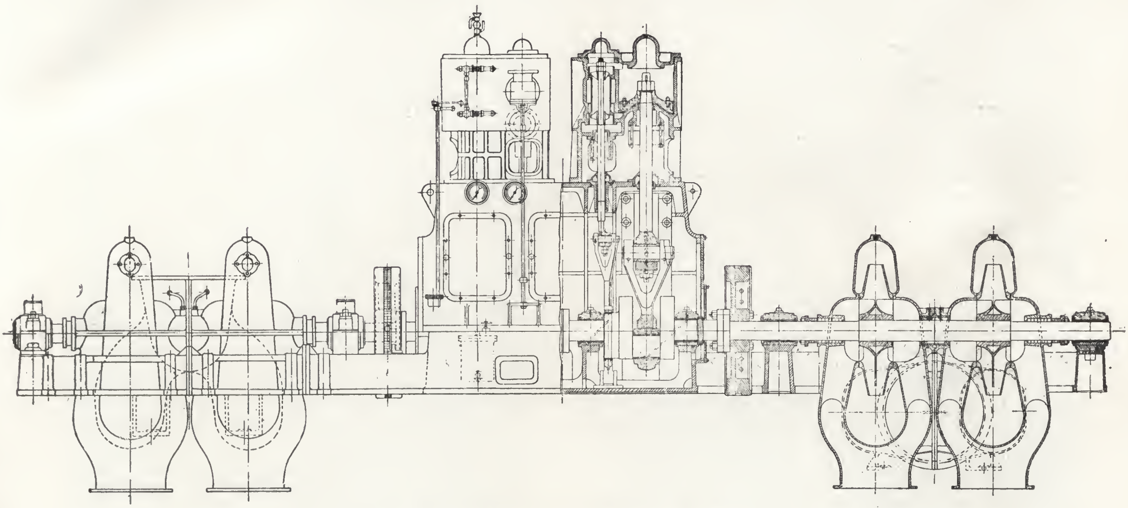


Fig. 80.—Main Circulating Pumps.

inches between the high-pressure turbine and the condenser. They have been constructed by Messrs. Glenfield & Kennedy, Ltd., of Kilmarnock, for a working steam pressure of 30lbs. per square inch. The appearance of one of the 75-in. valves is illustrated by Fig. 67. The body was cast in halves, which were afterwards machined and bolted together. The valve door is of circular box construction, with a gunmetal ring of heavy section forming the valve face, a similar ring being fixed to the valve body. To reduce friction as much as possible, the door rests upon two gunmetal rollers which run on a machined gunmetal path, these rollers being fitted with roller bearings. The door is opened and shut by means of two forged bronze spindles, which are supported in the door by gunmetal tubes to prevent sagging, the spindles being actuated by cast steel worm wheels. The worms are forged upon a mild steel shaft, which is operated by a 12 B.H.P. motor running at 1,150 revolutions per minute, the latter being controlled from the starting platform. To allow operation of the valve by hand power, should this ever be necessary, a bevel wheel and pinion are fixed in the worm shaft, the pinion being turned by a wrought iron cranked handle. The two 60-inch valves have gearing of a similar kind except that the door is operated by one spindle instead of two.

The exhaust connections from the low-pressure turbines to the condensers required to be of such immense size that the adoption of a square pipe was necessitated, as shown in Fig. 68. Special difficulties had also to be encountered owing to the fact that the pipes had to pass through a rigid watertight bulkhead, while the turbine casings expand considerably both in a longitudinal and a vertical direction when under steam, and if straining occurred the condenser vacuum might be impaired. To provide for expansion in the fore and aft direction, a copper expansion piece is fitted between the turbine and the bulkhead, while vertical expansion is provided for by a specially designed slipper guide on the bulkhead, which allows movement in this direction. All the steam and exhaust pipes are carefully insulated by Newall's magnesia coverings to prevent loss of heat by radiation.

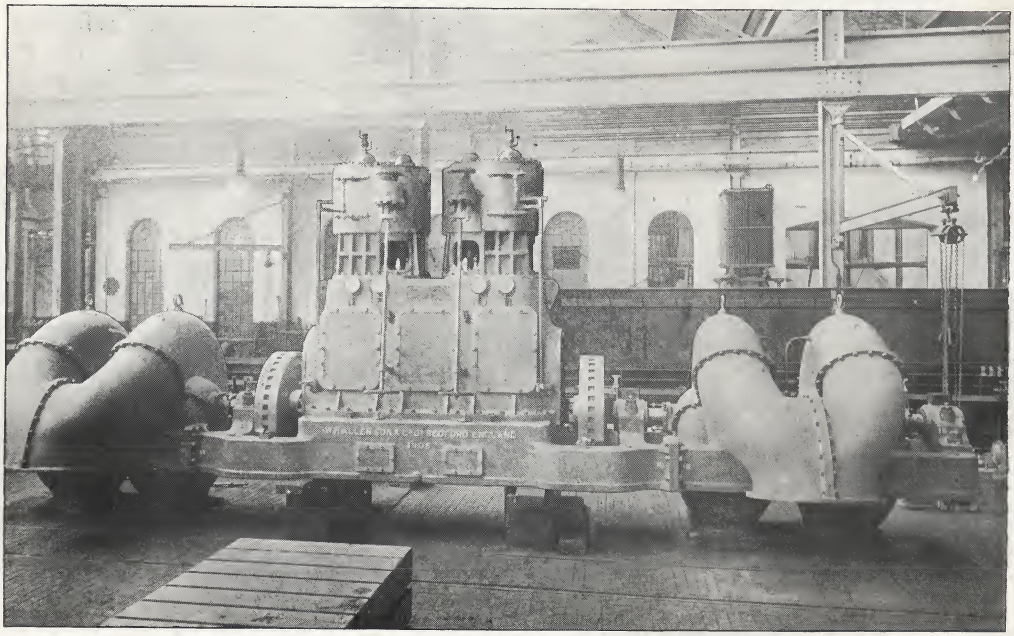


Fig. 81.—One Set of Main Circulating Pumps.

* * * *

The Turbines.

Some idea of the immense size of the turbines may be gathered from Figs. 69 and 70, which show a complete set erected in the

shops, and by the subsequent photographs (Figs. 71, 72, 73 and 74) illustrating their component parts. The turbine casings are of cast iron, while the rotors are of Whitworth fluid compressed steel and were machined out of solid ingots. The lathe upon which this work was accomplished is illustrated in Fig. 74, and has already been referred to in the description of the builders' works. The disc wheels of the rotors are also of the same material. Owing to the great peripheral speed of the turbine rotors, which amounts to from 10,000 to 11,000 feet per minute in the case of the high-pressure rotors associated with a very fine clearance between the blades and the casing, their accurate adjustment was very necessary. The turbine casings are firmly fixed at one end, but are free to move in a longitudinal direction at the other end to provide for expansion, the free end working between slipper guides. The bearings are spherical in form and all work under forced lubrication, the oil pumps for this purpose, of which there are six, being placed in a well at the centre of the low-pressure engine room between the low-pressure and astern turbine thrust blocks.

As regards the turbine blading, the builders, after making very complete investigations and experiments, decided to adopt a modified form of the Willans & Robinson system, combined with the usual Parsons method of binding. The blades are securely fixed by hand into slots prepared in the foundation ring by a special automatic tool, and formed into finished segments, the number of segments to form one complete ring of blades being ten, as shown by Figs. 75 and 76. In this way, great accuracy of pitch is secured. The segments are fixed in the annular grooves prepared for their reception, by means of side-caulked strips, the latter being in one or two layers according to the depth of the groove. The method of assembling the foundation ring segments with their blades afforded a considerable saving in time and labour compared with the previous Parsons

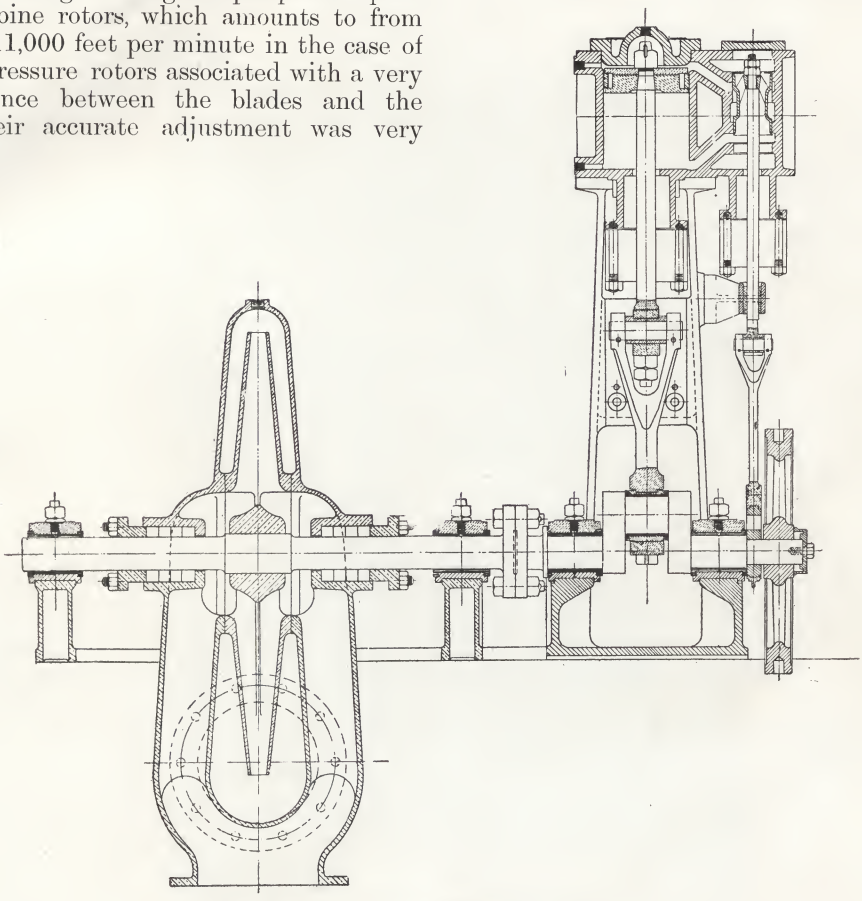


Fig. 82.—Auxiliary Circulating Pump.

practice of fitting each blade separately, and it enabled considerable progress to be made with the work before the casings and rotors were completed. The only soldering to be done in position on the rotor or casing was that required for connecting several unlaced blades, which had been left free at the ends to receive the lacing from the adjoining segment.

The line shafting is of Whitworth steel, made by Sir W. G. Armstrong, Whitworth & Co., and is hollow in all cases. Each line of shafting is provided with a Denny-Johnson torsion meter for measuring the power transmitted.

Arrangements for turning the turbines when in port are provided upon each shaft, and consist of an electric motor driving the shaft by means of a Renold's chain, as shown in Fig. 68. The arrangements for lifting the turbines for overhauling purposes, which required careful consideration owing to the large weights to be dealt with, are illustrated in section on Fig. 68 and in plan upon Fig. 77. Each turbine is provided with two sets of gear, both sets being driven simultaneously by Renold's chain belts from a counter-shaft driven by an electric motor. Each set consists of a large screw attached at its lower end to the turbine casing and also to a cast steel girder, which is guided by two strong girder columns when lifting. This screw is worked by a worm wheel, which is supported on ball bearings made by the Hoffman Ball Bearing Co., the worm gear being driven by the Renold's chain belt already referred to. Each set is mounted upon a strong beam built into the ship. All the lifting and turning gear motors have been supplied by the Lancashire Dynamo Co. and are worked by ordinary tram-car controllers.

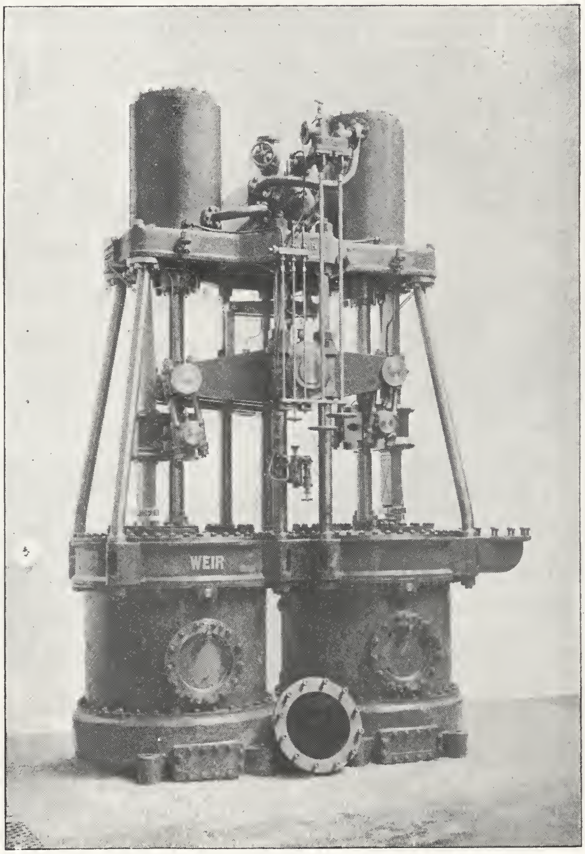


Fig. 83.—Wet-air Pumps.

Condensers. THERE are two main condensers, the cooling surface in each being about 41,500 square feet. Their appearance and construction is shown by Fig. 78. The shell is built of steel plates except at the ends which are of gun-metal, and they are fitted with the necessary sight holes and examination doors. The tube plates, which were made by Messrs. Vivian and Sons, are of unusual size, as shown by our illustration Fig. 79. The billets from which the largest tube plates were made weighed over $4\frac{1}{2}$ tons each, measuring 6ft. 3in. by 4ft. 8in. by 8in. thick, and the plates on the completion of the rolling measured over 200 square feet, the exact dimensions being 20ft. long by 10ft. 3in. wide by $1\frac{1}{8}$in. thick. The tubes are $\frac{3}{4}$-in. external diameter and 18 w.g. thick. Each condenser is fitted with the Harris-Anderson patent condenser tube protector. The circulating water inlets, of which there are two in each condenser, are 32in. diameter, the water being directed to pass through the lower nest of tubes and returned through the upper nest, from whence it is discharged overboard through large gun-metal valves on the ship's skin.

There are two auxiliary condensers of the Morison Contralfo type. As in the main condensers, the tubes are $\frac{3}{4}$-in. external diameter and 18 w.g. thick. These condensers are capable of dealing with all the auxiliary exhausts and turbo exhaust, when the surface or direct contact heaters are not working.

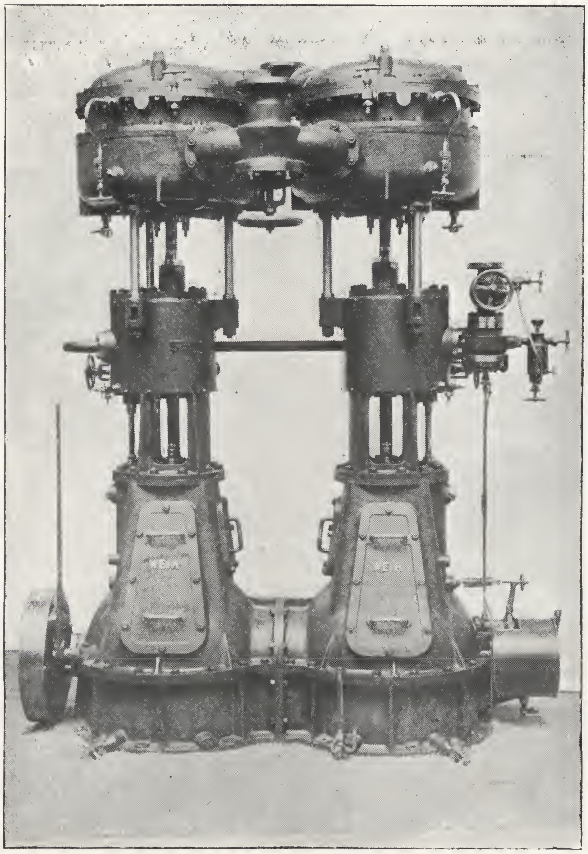


Fig. 84.—Dry-air Pumps

* * * *

Circulating Pumps. THE main circulating pumps have been supplied by Messrs. W. H. Allen, Son & Co., Ltd., Bedford. The installation is the largest of its type afloat, and is divided into two groups, one in each auxiliary machinery room. Each group

consists of four of the makers' well-known "Conqueror" type of centrifugal pump and two of their single-cylinder high-speed forced lubricating engines. The pumps are arranged in pairs in parallel, each pair being driven by one engine. The suction and discharge branches are 22in. diameter on the separate pumps, but the discharge branches from each separate pair unite into a common discharge pipe 32in. diameter. The whole arrangement may be clearly seen from the illustrations in Figs. 80 and 81, and embodies the most up-to-date practice for this class of machinery. On reference to Fig. 80, it will be seen that by means of a loose coupling, the engine shafts can be coupled together if desired, each set then consisting of a pair of two-cylinder high-pressure engines driving two pairs of pumps. Weights have been provided whereby the engines are properly balanced under these conditions. The diameter of each cylinder is 18in. with a stroke of 10in., and each engine is capable of developing 350 B.H.P. when running at 300 revolutions per minute with 160lbs. per square inch steam pressure at the stop valve and exhausting against a back pressure of 10lbs. per square inch. The distribution of the steam is effected by means of piston valves.

The main pump casings and impellers are of gunmetal, the casings being $\frac{9}{16}$-in. thick and the impellers 42in. diameter. The pump spindle is of forged bronze carried in bearings external to the pump casing. To ensure a perfectly tight joint where it passes through this casing, stuffing boxes with gunmetal glands and adequate oiling arrangements have been fitted.

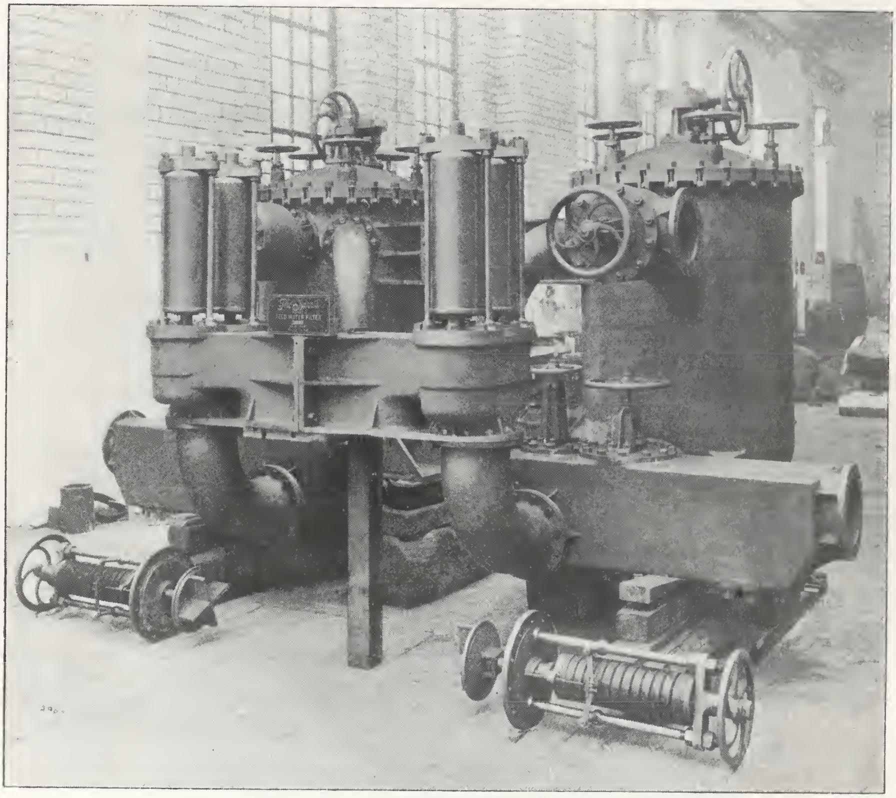


Fig. 85.—Feed Filter Apparatus.

Two auxiliary circulating pump installations have also been supplied by Messrs. Allen, each set consisting of one of their standard single-cylinder open-type engines coupled to one of their gunmetal pumps, as illustrated in Fig. 82. The engine cylinder has a diameter of 7in. with a stroke of 10in. The pump impeller is

of gunmetal 36in. diameter, and the pump suction and delivery branches are 10in. diameter. The pump spindle is of forged bronze, carried on bearings external to the pump casing in a manner similar to that adopted for the main pumps.

* * * *

Air Pumps.

THE main air pump installation consists of four sets of wet-air pumps and four sets of dry-air pumps, all supplied by Messrs. G. and J. Weir, Ltd. Two sets of pumps are placed in each auxiliary room and draw from each condenser. Each wet-air pump has two steam cylinders and two pump barrels, with the pump rods cross-connected by a beam, as shown by Fig. 83. Steam is admitted to both cylinders by a steam valve of the Weir special air-pump type. This valve embodies the well-known features of the Weir steam valve, but is specially adapted for air-pump duty. The pump barrels, the buckets, and the head and foot valve seats and guards are of gunmetal. The valves are of the Kinghorn type. The cylinders are supported on a cast iron entablature set on angle wrought iron columns. The piston rods are of steel, connected by a crosshead with pump rods of manganese bronze, working in vertical guides. The wet-air pumps are capable of maintaining the required vacuum; but in order to deal with any unexpected leakage, the dry-air pumps are fitted. The latter pumps, which are illustrated in Fig. 84, are 24in. diameter by 7in. stroke and deal with air only. Their pump chambers are situated over the steam cylinders of a double connected enclosed high-speed engine. The chambers are of gunmetal and are of the single-acting type. The air passes into the barrel above the buckets through annular openings and is forced through the head valves on the up-stroke of the pump. A certain rise of temperature takes place as a result of the compression of the air, but the heat is carried off by a small supply of circulating water which passes through the chamber. Steam is admitted to the engine by a piston valve, controlled by a governor fitted on the shaft in the usual manner. All the main air pumps discharge directly into the hot-well tanks.

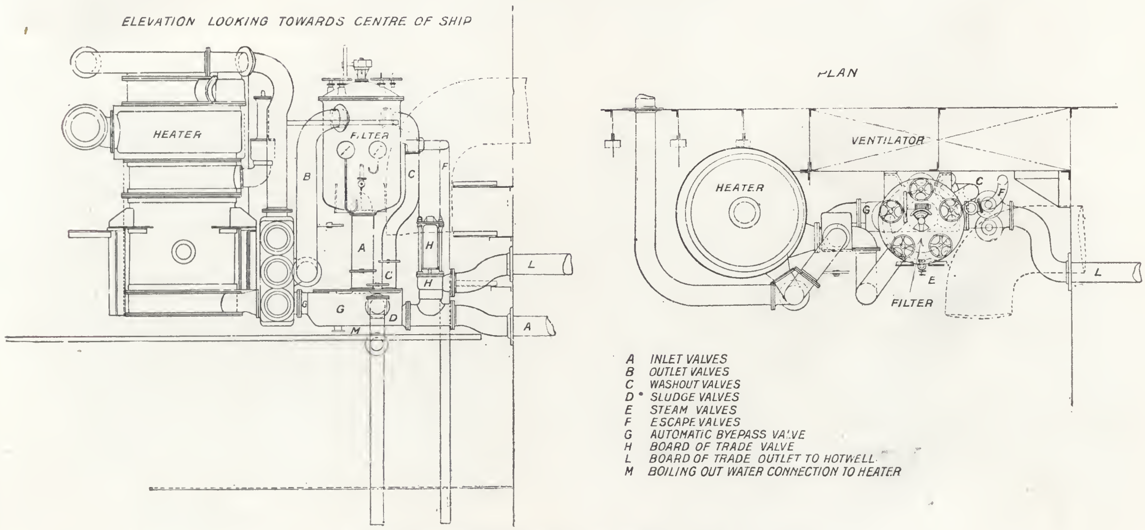


Fig. 86.—Arrangement of Main Feed Filter.

An auxiliary air pump, also made by Messrs. G. & J. Weir, is fitted for each auxiliary condenser. These pumps are single-acting and known as Weir's "Monotype." From each auxiliary air pump the water passes through a Harris auxiliary feed filter and thence into the hot-well tanks.

* * * *

The Return Feed System.

THE hot-well tanks are situated underneath the main condensers, and are two in number, arranged for working either together or independently. The water is taken from the hot-well tanks by four hot-well pumps of Messrs. Weir's make, $14\frac{1}{2}$in. by 30in., which are placed at the after end of the L.P. room in close proximity to the tanks from

which they draw. These pumps are arranged to take steam either by direct or by automatic control. The automatic controlling arrangement consists of a float in each hot-well tank, which operates a control cock taking steam from

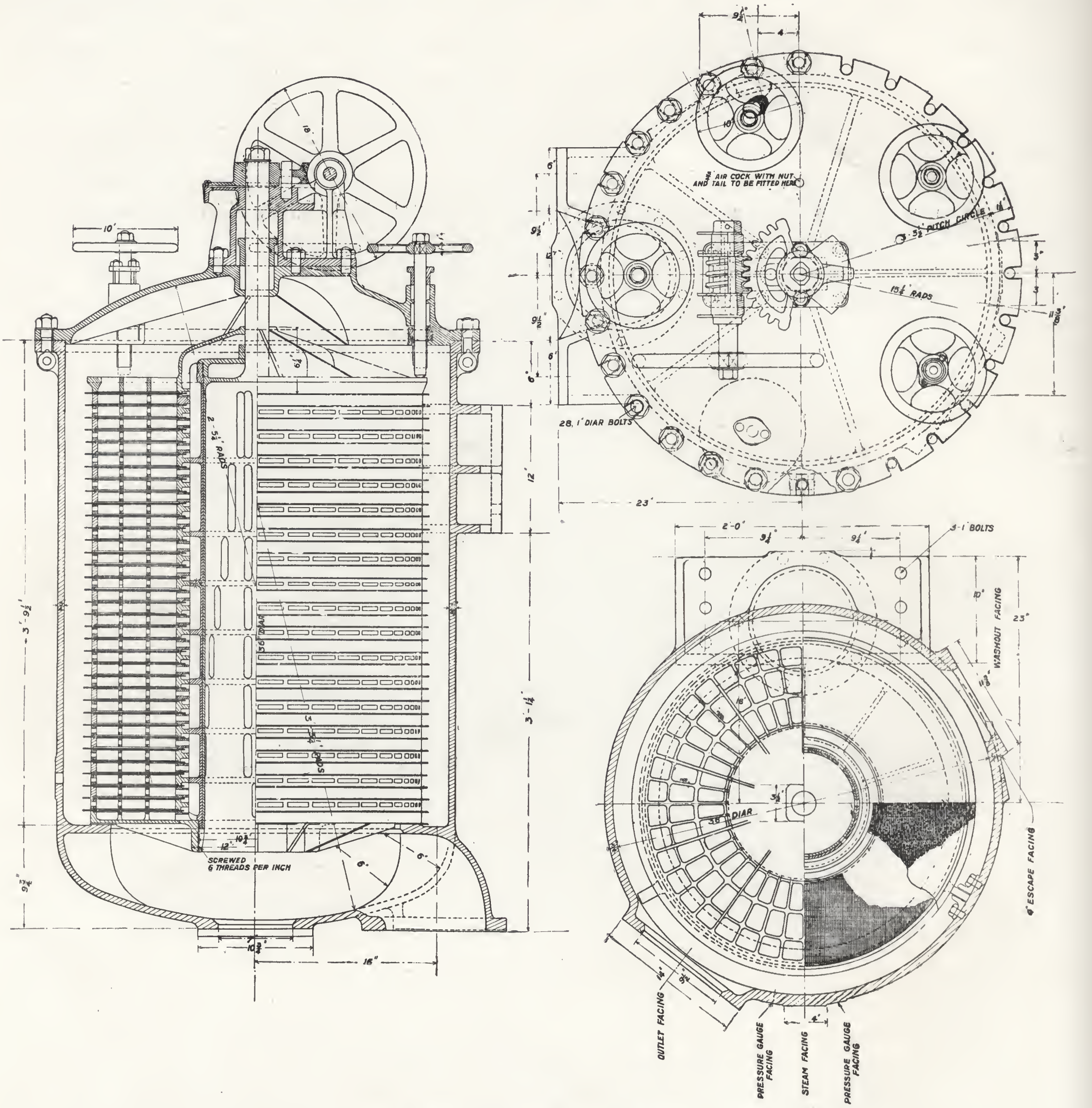


Fig. 87.—36-in. G. M. Filters.

the auxiliary range. The outlet from this cock is connected to a second control cock regulated by a float in the direct-contact heater, the outlet from the second cock being connected to a steam valve on the pump. The pumps are thus controlled both on the suction and discharge side. From the hot-well pumps the water passes through the main feed filters to the Weir surface feed-heaters.

The feed-water filters, of the well-known Harris type (see Figs. 85, 86, and 87), were supplied by the Harris Patent Feed Water Filters, Limited, Newcastle-on-Tyne. The filters are each 36in. diameter and of gun-metal throughout, the principal features in their internal construction, shown in Fig. 87, being the central sludge outlet, an ingenious arrangement by which the filtering area is divided into eight separate sections each of

which can be sludged out independently of the rest, the whole force of the reversed current of the water when cleaning being concentrated on only one-eighth of the surface, so that the cleaning is most efficient, and can be effected in a few minutes without the necessity of opening out. The filters present a most compact appearance, and everything is well arranged to facilitate their ready manipulation. Two smaller filters, $20\frac{3}{4}$in. internal diameter, also of gunmetal, are fitted in connection with the auxiliary machinery. These filters are of the same type as the larger ones, but with all the valves self-contained.

In the surface feed-heaters the water is arranged to enter at the bottom and travel through the tubes which are vertical, being heated in its passage by the exhaust from the auxiliaries which circulates round the outside of the tubes. All the auxiliaries, with the exception of the turbo-generators, can exhaust into the surface heaters; and as heat is given up to the feed-water, the exhaust steam is condensed and returns as water to the hot-well tanks. The advantage of adopting the surface feed-heaters is that heat is taken from the exhaust without any oil being admitted into the feed system. From the surface feed-heaters the water passes either directly or through the direct-contact heaters to the main or auxiliary feed pumps, and thence is discharged into the main-feed ranges. In the direct-contact heaters, which are also of Weir's make, the water is raised to a still higher temperature by direct mixture with exhaust steam which has passed into the contact heater from the turbo-generators, and with vapour which has passed in from the feed make-up evaporators. As already stated, four sets of main feed pumps are fitted in the engine rooms, and the feed discharge pipes are so arranged that each boiler room can be fed by one of these pumps through an independent pipe. Two sets of auxiliary feed pumps are fitted in recesses at the ends of No. 2 and No. 3 boiler rooms, and an auxiliary feed and ash ejector pump is fitted in each boiler room. Two wrought iron tanks, fitted with control gear, regulate the working of the ash ejector pumps. All these pumps are of Weir's make, and are connected to either range of the feed discharge pipes. The feed pumps are Weir's standard type, being $13\frac{1}{2}$in. diameter by 30in. stroke. They have water ends entirely of gunmetal, fitted with gunmetal liners, gunmetal buckets, manganese bronze pump rods, steel piston rods, bronze valves in gunmetal seats, and suction and discharge stop valves. The distributing valves for the boilers are placed on the bulkheads at a convenient position in each stokehold. All pumps in the boiler rooms are cased in to prevent the access of coal dust to the working parts.

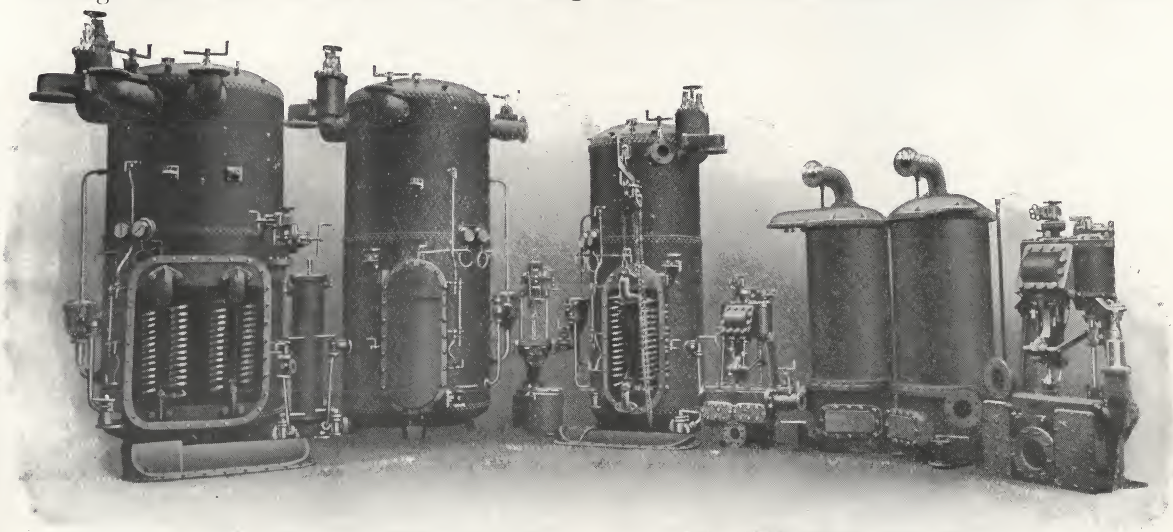


Fig. 88.—Evaporators and Distillers.

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Evaporating Plant.

Two complete sets of evaporating plant have been supplied by the Liverpool Engineering & Condenser Co., Ltd., the various parts being shown by Fig. 88.

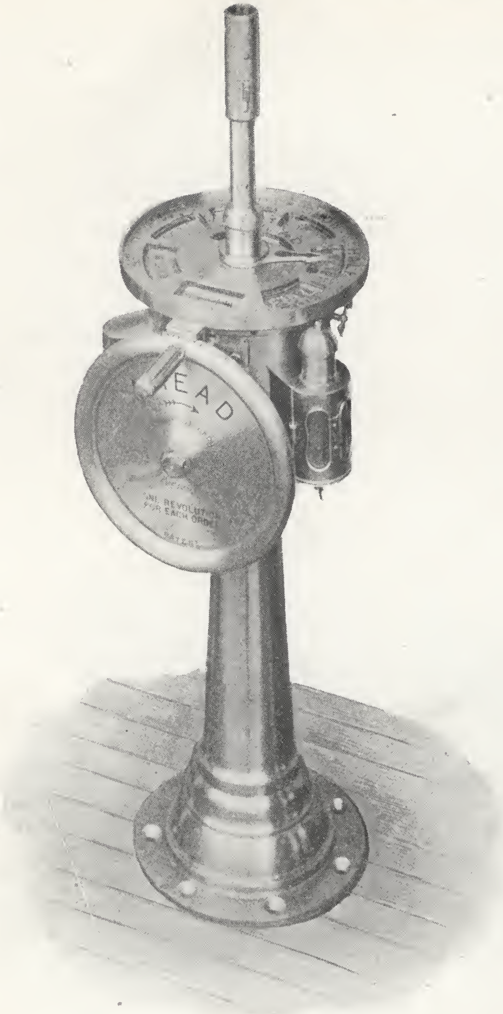


Fig. 89.—Bridge Transmitter.

Each set consists of one evaporator for the production of distilled water with two distilling condensers, one for drinking water and the other for washing water for the ship's use, and two evaporators for feed make-up purposes, the latter being arranged to work in series or separately. The capacity of each plant for the production of distilled water is 18,000 gallons per 24 hours for cooking and drinking purposes, and 15,000 gallons per day for baths and washing; while feed water is supplied by the feed make-up evaporators of each set at the rate of 240 tons per day when working in series, and 350 tons per day when working separately.

The evaporator stills are of rolled naval brass and the ends of gunmetal. The distilling condensers have shells of galvanised steel. The pumps supplied with each set are three in number, and consist of one brine pump of the single-cylinder double-acting type, one evaporator feed pump of the duplex type, and one circulating pump for the distilling condensers also of the duplex type.

* * * *

Sundry Pumps.

In addition to the pumps already described, a large number of pumps have been fitted for various duties. One fire pump and two sanitary-service pumps of Messrs. Weir's duplex type, 10in. diameter by 10in. stroke, are situated in the L.P. engine room between the astern turbines. Messrs. Weir have also supplied four single direct-acting bilge pumps 10in. diameter by 21in. stroke; and also the oil pumps, six in number, which are specially designed to supply oil to the turbine bearings. The oil pumps are direct-acting and have cylinders 8½in. diameter by 15in. stroke. Several pumps have also been supplied by Messrs. J. H. Carruthers & Co., Glasgow, including two water-service pumps of the duplex type placed next to the sanitary pumps between the astern turbines, and the fresh-water and condensed-water pumps which are placed in the port H.P. engine room. Both the latter

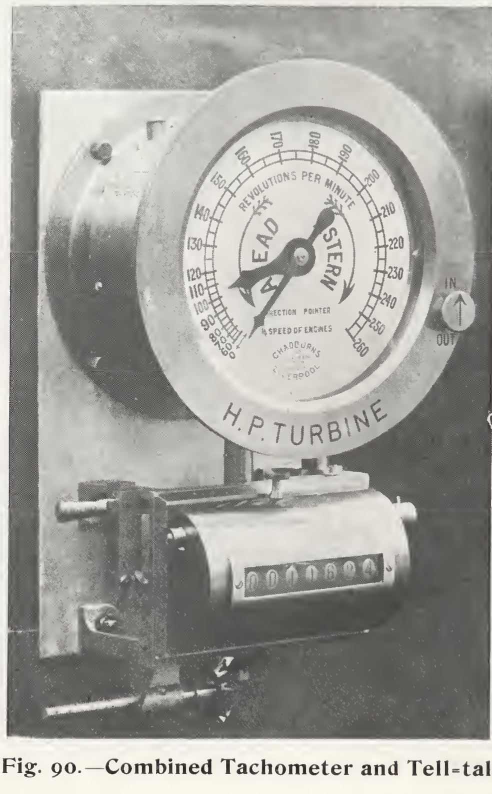


Fig. 90.—Combined Tachometer and Tell-tale.

are arranged to draw from the fresh-water tanks aft and the reserve fresh-water tanks in the double bottom. The fresh-water pump discharges through a filter, from whence the water is directed forward, aft or amidships. The condensed-water pump, in addition to discharging forward or amidships, can also discharge into the hot-well tank for feed make-up purposes. Two ballast pumps supplied by Messrs. Carruthers are fitted in No. 1 boiler room.

* * * *

Engine Telegraphs.

THE engine telegraphs have been supplied and fitted by Chadburn's (Ship) Telegraph Co., Limited. The question of the most reliable method of communicating orders from the bridge to the engine room in this vessel was of vital importance, and presented certain difficulties which were a cause of much thought to the designers. Owing to the great length of the vessel, the distance between the transmitting station on the bridge and the receiving station on the starting platform was unprecedentedly great, and rendered the use of the ordinary type of telegraph, with wire and chain connections, inadmissible, owing to the danger of its breaking down. It was therefore decided to use Messrs. Chadburn's patent "Wheel Handle" telegraph, of the type adopted in the British, and most up-to-date Navies.

One of the four bridge transmitters is illustrated in Fig. 89. These transmitters are larger than the ordinary naval pattern and are connected by hollow cold-drawn weldless steel tubes and machine-cut gunmetal bevel gearing to their respective indicators in the engine room. It will thus be seen that each of the four lines of main shafting is controlled by a separate telegraph from the bridge; the two H.P. turbines having "ahead" orders only, while the two L.P. shafts, which carry the reversing turbines, are governed by telegraphs carrying both "ahead" and "astern" orders.

It is very necessary that the telegraph should be absolutely reliable and at the same time easy to work; and as each lead is over 600 feet long, Messrs. Chadburn proposed—and it was decided—to use ball bearings of a special design for the purpose of reducing friction to a minimum. These bearings support the shaft on hardened steel races, and at the same time allow it to move longitudinally so as to accommodate itself to variation in length arising from differences of temperature in passing through the boiler room. This proved very satisfactory, allowing the great weight of gearing with the heavy gongs and indicators to be manipulated from the bridge with ease, with one hand. In addition to the transmitters, there are on the bridge two tell-tales, whose pointers are driven by similar shafting and gearing from worm gear on the main turbine shafts themselves. Thus every movement of the engine is immediately and faithfully copied on the bridge, forming the best possible "reply" to the Captain's orders. The engineer also acknowledges the order by means of electric single-stroke gongs, which ring on the bridge when the push is pressed in the engine room.

The order having been received, the engineer next turns his attention to the starting gear, and the result of his manipulations is shown by the patent combined tachometer and tell-tale manufactured by Messrs. Chadburn, and illustrated by Fig. 90. This instrument has two pointers, one showing the direction of rotation of the main shaft and the other the speed of rotation. The dial is graduated in revolutions per minute, and the tachometer pointer indicates the speed whether the turbine is running ahead or astern. Attached to the combined tachometer and tell-tale is the counter, which shows the total number of revolutions run.

Owing to the distance of the boiler rooms from the starting platform, a system of telegraphs by Messrs. A. Robinson & Co., Ltd., has been fitted between the engine and boiler rooms, so that the engineer in charge can give certain orders to each boiler room. He can inform the stokehold chargeman when the engines are running full-speed, half-speed or slow, if the watertight doors are to be closed, and if the firemen are to go to the escape. He can also be informed from the boiler room about the supply of feed water.

* * * *

Ventilation of the Engine Room.

THE ventilating trunks from the engine room are carried well above the top deck, and are fitted with large cowls of the ordinary type. The artificial ventilation consists of twelve large "sirocco" fans, which have been supplied by Messrs. Davidson & Co., Belfast. Six of these fans are for driving air in, and the other six for exhausting hot and foul air. Four smaller fans are arranged to exhaust air from underneath the engine room platform, the trunks for the passage of air to the fans being formed by plating over adjacent channel stiffeners on the longitudinal bulkhead.

Passenger Accommodation.

THE passenger accommodation of the *Mauretania*, when its spaciousness and beauty of decoration are taken into account, certainly justifies the use of the somewhat extravagant term "a floating palace." It is claimed that the vessel offers 50 per cent. more light and air space and deck promenade per passenger than any other liner afloat with the exception of the *Lusitania*. In the internal decorations an entirely fresh departure has been made, and the effect is unlike anything we have previously seen. The following list gives the accommodation provided:—

First-class passengers	....	560
Second-class do.	....	475
Third-class do.	....	1,300
Total	....	2,335

The vessel, therefore, with her crew of 812, carries a grand total of 3,147 persons. There are in all 664 staterooms provided for passengers as well as the numerous public rooms referred to later. The greater part of the accommodation for passengers, officers and crew has been carried out by the shipbuilders in their own workshops, Mr. W. C. Phipps, the company's head foreman joiner, having had charge of the woodwork throughout the construction of the vessel. The following work has been done by sub-contractors:—The first-class lounge and library, by Messrs. C. Mellier & Co., London; the first-class dining rooms, smoking room, grand entrances, 54 special staterooms, and the regal suites, by Messrs. W. Turner Lord & Co., London; and the children's room and 14 special staterooms, by Messrs. Robson & Sons, Newcastle-on-Tyne. Mr. H. A. Peto has been the architect for the decorations, and his designs have been carried out with a zeal and care

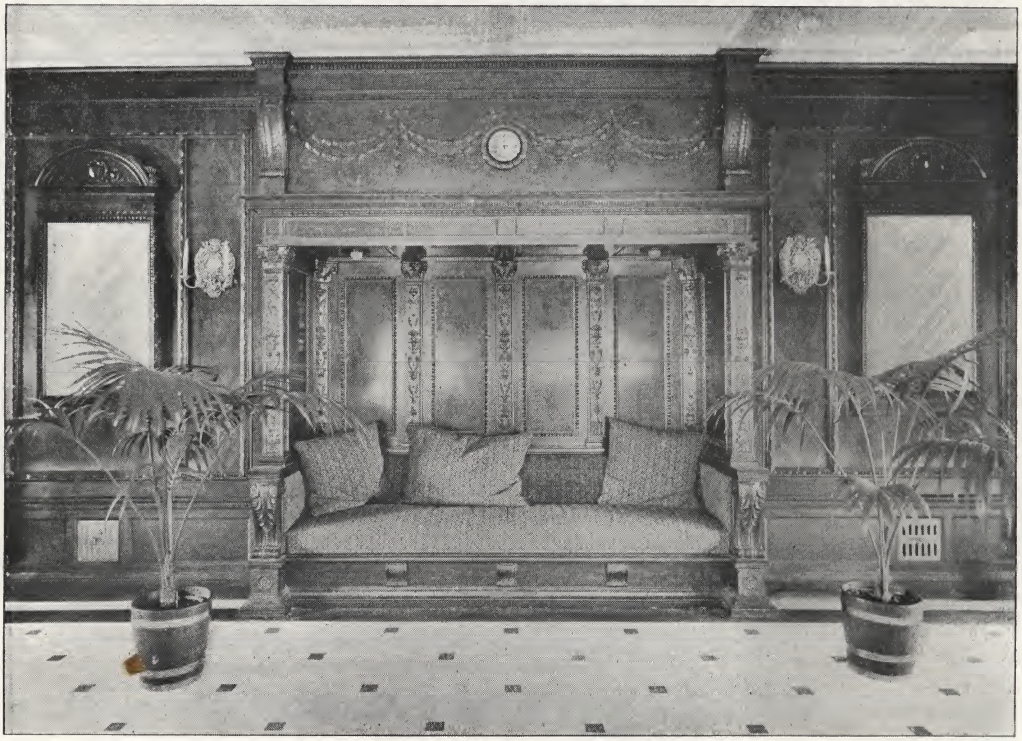


Fig. 91.—Seat in Entrance on Boat Deck.

seldom equalled. The result is a succession of splendid rooms and halls treated in the Italian and French Renaissance of the fifteenth and sixteenth centuries, worthy of the beautiful palaces of that period. The whole effect is rich and interesting, and may fairly be described as a triumph for all concerned.

* * * *

First-class Accommodation.

As will be seen from Plates V. and VI., the accommodation for first-class passengers, placed amidships, extends over five decks—the main, upper, shelter, promenade and boat decks. Access from one deck to another is obtained by means of the grand and other staircases, and by two separate electric passenger lifts, which travel from the main to the boat deck.

* * * *

Grand Entrances and Staircase.

THE grand entrances and staircase are treated in the fifteenth century Italian manner. The woodwork is French walnut, the panels being veneered with some of the finest figured wood that one could wish to see. The utmost difficulty was experienced in obtaining a sufficient quantity of veneers of the quality aimed at for so extensive a work, both England and France being searched for what was needed. The carving of the woodwork in the entrances and staircase is much less than in the dining saloons, which will be described later, but the panels that contain carving are very chaste in design and workmanship. The carved capitols of both pilasters and columns are interesting, on account of the variety of design. In recesses in two of the entrances are carved sedia or seats (see Fig. 91), which remind one of the days of the Medici.

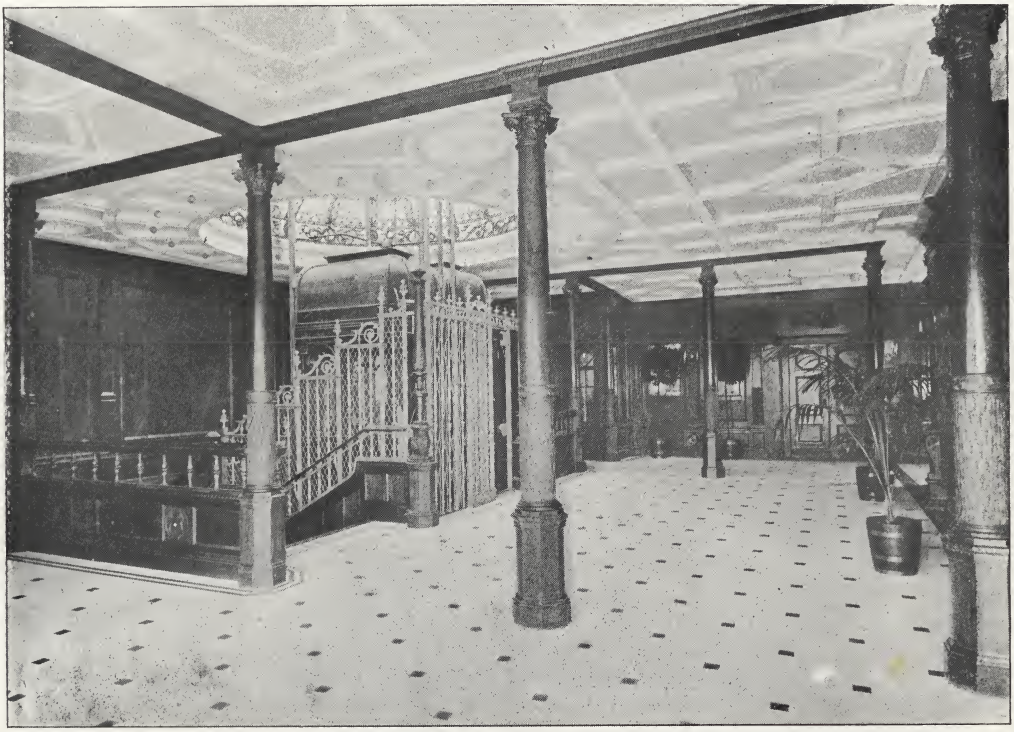


Fig. 92.—Entrance on Boat Deck, showing Lifts.

The grand staircase is unequalled in size and beauty in any vessel afloat, and indeed it is worthy of any mansion ashore. The two lifts, or elevators, the mechanical arrangement of which is described elsewhere, are arranged in the well of the staircase. The "grille" or railing round the lifts is of aluminium, the design being adopted from some antique

Photo by] **Fig. 93.—First-class Dining Saloons.** [*J. S. Dodds.*

Fig. 94.—Upper Dining Saloon and Dome.

Fig. 95.—Another View of Upper Dining Saloon

Fig. 96.—A Corner in Lower Dining Saloon.

wrought ironwork of the fifteenth century. We do not remember having previously seen a "grille" made of aluminium, and the soft tone of the metal gives a cheerfulness to the more sombre walnut woodwork. A considerable saving in weight has been effected by using aluminium instead of iron or bronze—an important consideration in the design of high-speed vessels. Another fine piece of aluminium work is that in the bureau front on the promenade deck.

In all the grand entrances a pleasant foothold is given by the indiarubber tiling, supplied by the India Rubber, Gutta Percha and Telegraph Works Co., Ltd., of Silvertown; and the carpet on the stairs is of a delightful shade in green, serving to accentuate the beauty of the panelling.

Fig. 97.—A Bay in First-class Lounge.

* * * *

Dining Saloons.

FIRST in importance in regard to size are the two first-class dining saloons—the upper and the lower—situated on the upper and shelter decks. Between the two rooms is a large open space surmounted by a dome, the whole producing a lofty and airy effect. The dining rooms are panelled in straw-coloured oak, in the style of Francis I. One of the charms of this style is that no piece of carving is an exact reproduction of its neighbour, and an inspection of these apartments will show how well the designer has followed the traditions of the style. Some of the most delicate work is shown upon the arched bulkheads which run at right angles to the sides of the ship All the carving in these rooms has been cut back from the face of the solid wood. The aim of the designer has been to keep the larger and lower room richer in carving, leading up to a simpler treatment of the upper dining saloon, and terminating with the crowning feature of the dome. This dome is a groined one, in cream and gold, reminding us of the Chateau de Blois. The interlacing of the groins has been carefully planned, with small enriched circles at the cross sections, introducing the signs of the Zodiac. At the top is an octagonal balustrade, through

which hidden electric lamps throw light against a gilded convex disc, shedding a soft glow like warm sunlight over the apartments. The sconces in the upper dining saloon are well worthy of attention, being reproduced from a fine pair of antique silver ones.

The rooms are upholstered in deep pink, and a fine sixteenth century tapestry at one end of the lower apartment gives an admirable effect. The floor of the lower dining room, as well as of other apartments, is laid with parquetry by the Turpins Company, of London, and the carpet is in a pleasing tone of cerise red. The long tables usually found in the dining saloons of the older Atlantic liners have been discarded, and small tables have been adopted in both the lower and upper dining saloons. In the lower saloon the tables accommodate from 5 to 14 passengers, and in the upper saloon parties of from 2 to 6 persons can be seated at each table. The lower room, which is 87 feet long, extends the full width of the ship and is thus almost square, and provides seating accommodation for 328 passengers. The upper dining room is 62 feet long by 66 feet wide, and seats 152 persons. The height from the floor of the lower dining saloon to the top of the dome is about 28 feet.

* * * *

Lounge and Music Room.

THE first-class lounge or music room, situated on the boat deck, is 80ft. long, 56ft. wide, and 11ft. 9in. high. It is a noble apartment, treated in that charming style which obtained in France in the last quarter of the eighteenth century, and of which the Petit Trianon is perhaps the most typical example. The arrangement of the panels, and the delicacy and design of the carvings and columns, might have been the work of Gabriel or Miqué, but the architect has, in his scheme of colour, been inspired more by the sumptuous furniture of the period than by the wall decoration, and that with the happiest result. It is difficult at first to realise that one is afloat when in this beautifully-shaped room, with its rows of stately columns and its graceful semi-circular bays; and only those who know how a designer is

Fig. 98.—Another View of First-class Lounge.

Fig. 99.—First-class Smoking Room, looking forward.

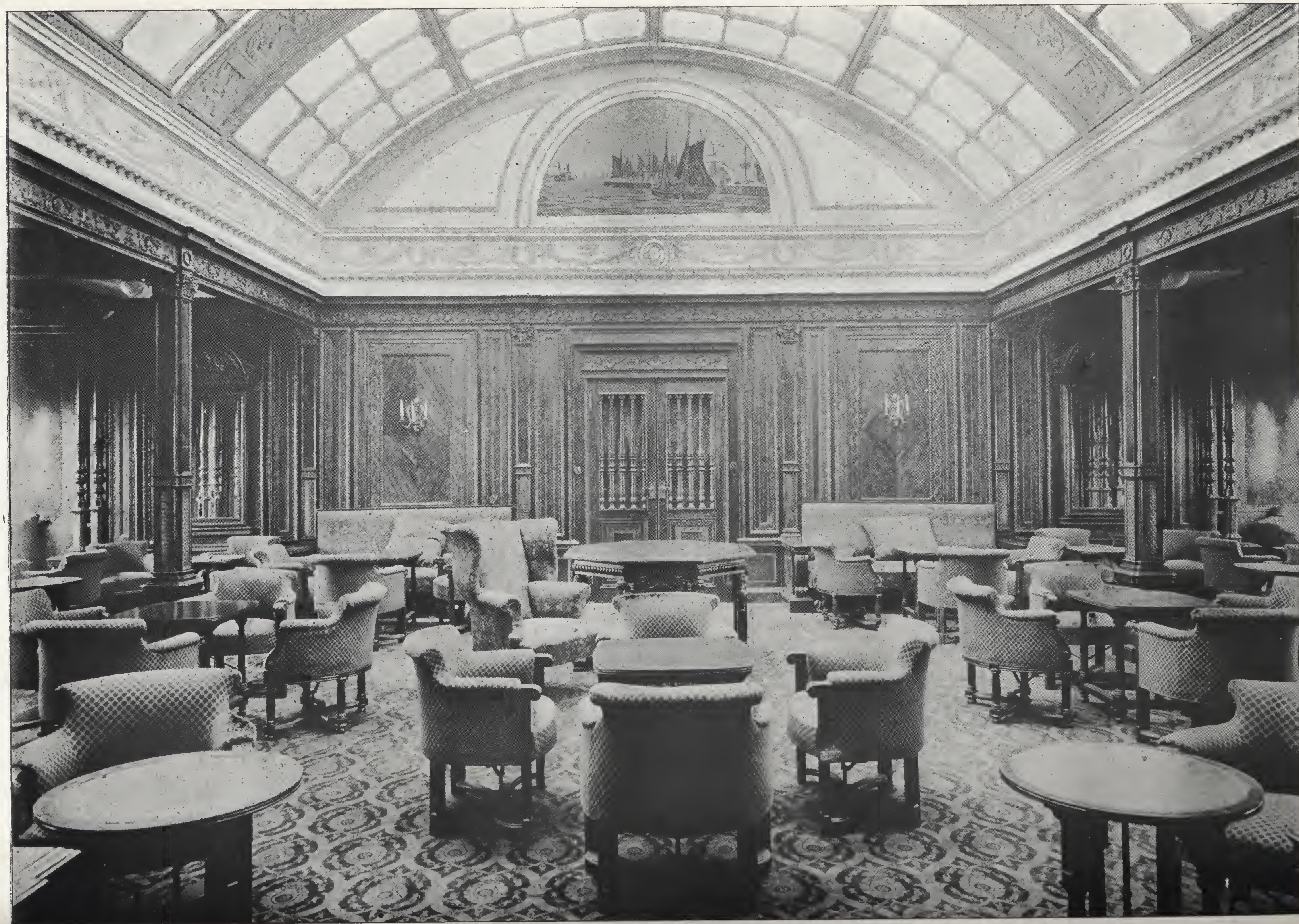


Fig. 100.—First-class Smoking Room, looking aft.

hampered by the position of funnels, ventilators, beams girders and the various necessities of the modern ship, can properly appreciate the ingenuity displayed. The panelling, columns and pilasters are of that mahogany which the French term *acajou moucheté.* The panels are of the same materials, soft creamy curtains with coloured borders, and three fine panels of French tapestry, produce a colour effect which leaves nothing to be desired. The oval dome of wrought iron with gilt ornaments, and the plainly panelled white ceiling from which are

Fig. 101.—An Entrance in the Smoking Room.

cross-veneered so as to give the greatest effect to the grain of the carefully-selected timber, which is dull polished a rich golden brown, the mouldings and all the carvings being fully gilt.

Sixteen pilasters of *Fleur de Pêche* marble with ormolu capitols and bases, a chimney-piece suspended crystal electroliers, complete a room unequalled in any steamship and rarely surpassed even in a palace.

The carpet and furniture are worthy of the decorations. The former, specially designed for this apartment, is of the same cream tone as

Fig. 102.—A Recess in First-class Smoking Room.

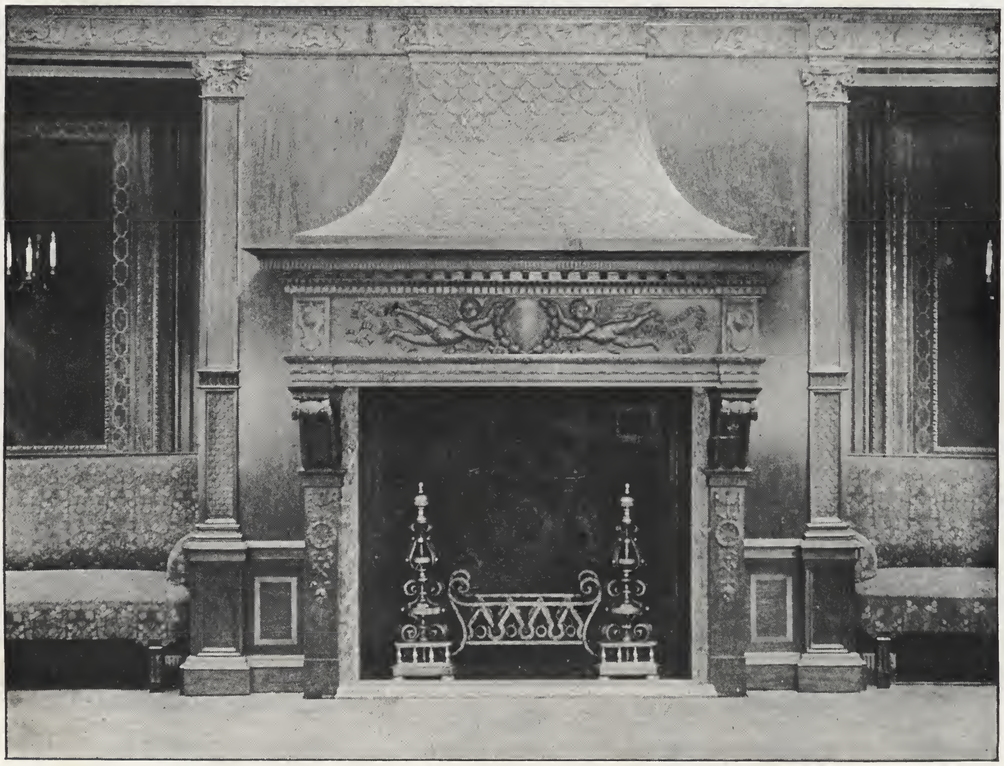


Fig. 103.—Fireplace in First-class Smoking Room.

FROM A PHOTO BY J. S. DODDS.

The First-class Music Room and Lounge of the "Mauretania."

the curtains with a trellis-work of laurel and roses, recalling in its turn the colours of the tapestry on the walls. The chairs and sofas, of polished beech covered in various coloured brocades, are all reproductions of Louis XVI. designs, combining elegance and comfort. The tables of various sizes, scattered about the room, are worthy of attention on account of their colouring and shapes, being entirely destitute of extraneous ornament.

bring out the fine grain, the plain portions of the wood being entirely discarded. As in the lounge, the carved mouldings are gilt, but the gold used has a slightly greenish tint to harmonise with the panelling. A bookcase forms the panelling of one side of the central portion of the room, the delicate carving and gilt trellis of the doors greatly enhancing the appearance of the wall. On the opposite side of the room is a carved chimney-piece of white

Fig. 104.—The Verandah Café.

Library and Writing Room.

THE library or writing room, a somewhat smaller room than the lounge, is situated on the same deck and is decorated in the same style, although the colour scheme is entirely different. This room will probably be regarded by many passengers as the most beautiful in colour in the ship, although we ourselves are inclined to award this distinction to the lounge. The wall panelling is of sycamore stained a silver grey. The veneering has been so selected as to statuary marble, surmounted by a mirror similar in design to the central doors of the bookcase, which it faces and reflects.

The carpets and curtains are of deep rose colour, the latter relieved by borders of coloured brocade. This colour also predominates in the covering of the seats. The frames of the seats are of mahogany, copied exactly from antique models, the original of one—a wide square *bergère* in the possession of Messrs. Mellier, the contractors—being, we believe, unique. The

writing and other tables, which have been specially designed, are also of mahogany. The treatment of the swing doors in this apartment as well as in the lounge is worthy of special attention. The panels are fitted with square bevelled glasses, the narrow dividing rails being of richly chased and gilt ormolu. By the use of clear glass panels in the doors, the range of view is much extended, reaching to the beautiful corridors and adjoining rooms, a total distance of about 350 feet. It only remains to be said that the ceiling and dome, the crystal chandeliers and other accessories of the library, are similar to those in the lounge, but quite distinct in detail.

* * * *

Smoking Room. THE smoking room, on the boat deck, is reached by a vestibule from the music room as well as by an entrance from the open-air promenade. It is 52ft. long and 50ft. wide, with a height of 11ft. 9in. The period selected for the decoration of this room is fifteenth century, Italian, in walnut, the same as the grand entrances. In carving, however, the smoking room is much richer, and it is relieved round all the panels with an inlaid border of sycamore. An interesting feature is a *jubé* extending the length of the room, and divided into recesses with divans and card tables. Two recesses at one end of the room, fitted with writing tables, give the users perfect seclusion. As will be seen by one of our illustrations, the windows in the recesses are unusually large for shipwork and are treated with semi-circular arches, giving them the appearance of the windows of a house ashore. The chimney-piece at the forward end of the room is a magnificent piece of work. It is surmounted by a carved wood hood, and has been modelled and carved from a fine example of Della Robbia in the South Kensington Museum. The sides

Fig. 105.—The Observation Room.

of the fireplace are lined with massive slabs of *Verte Campan* marble, and the basket grates and firedogs are reproduced from the originals at the Palazzo Varesi. The appearance of the smoking room is greatly enhanced by the waggon-headed roof, which is divided into three sections and decorated with beautifully modelled plaster-work. A frieze of plaster-work also runs round immediately above the carved cornice, and embraces a picture at each extreme end of the room, one representing "Old New York" and the other "Old Liverpool." The roof, together with the plaster-work, is all finished in vellum colour.

* * * *

Verandah Café. THE provision of a verandah café at the after end of the first-class smoking room on the boat deck is one of the many delightful innovations of the *Mauretania*. Here passengers may sit and sip their coffee in the open air, perfectly protected from the weather. Evergreens have been trained along the glazed roof, giving the passenger an impression of shore comforts. The furniture in the verandah café has been supplied by Mr. J. P White, of the Pyghtle Works, Bedford.

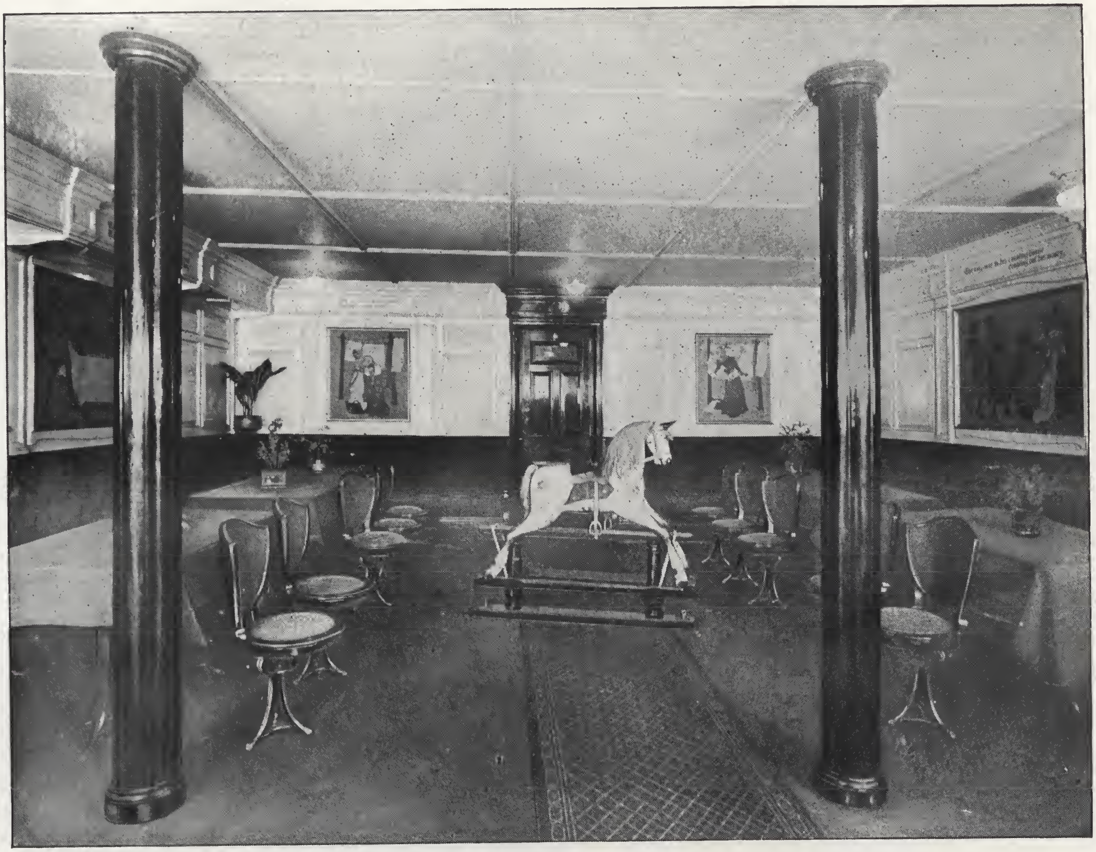


Fig. 106.—The Children's Room.

Observation Room. THIS apartment is situated on the promenade deck in the fore end of the deck-house and commands an uninterrupted view over the bow of the vessel while affording complete protection from the weather. Passengers are thus able to see the vessel forging ahead without being exposed to the force of the wind caused by the great speed at which the vessel travels.

Children's Room.

In this apartment, which is situated on the shelter deck and reached from the grand entrance, the work has been carried out in mahogany, white enamelled. The panelling on the walls is decorated with paintings by the well-known artist, Mr. J. E. Mitchell, of Newcastle-on-Tyne, illustrating the nursery rhyme "Four and Twenty Blackbirds." Dining tables and seats, of suitable height for little passengers, are provided; and the big rocking horse in the centre of the room will no doubt be much in demand. The windows in this room, as in the public rooms generally, are square, and not the usual circular lights used in shipwork. A children's lavatory and pantry, besides rooms for four stewardesses and two matrons, open off the children's room.

Fig. 107.—Panel in Children's Room.

* * * *

Regal Suites.

The two regal suites, one on each side of the promenade deck, comprise drawing room, dining room, two bedrooms, bathroom and private corridor. The drawing and dining rooms of the suite on the port side are panelled in East India satinwood, the veneers of the panels being laid across the angles which converge to the centres. In the drawing room gilding has been added, and a silk tabouret in a charming tone of green has been used in the wall panels. The rooms are heated by electric radiators, fitted with statuary marble mantelpieces. The style of these two apartments is a simple form of Adams, admirably adapted to rooms of this size. The two bedrooms are Georgian in character, with carved mouldings, and finished in white, the furniture being of mahogany. The wall panels are covered in silk corresponding to that used in the drawing room. The suite on the starboard side is carried out in a very similar style, with the exception that a delightful tone of rose is substituted for green. The dining room, which communicates with the drawing room by sliding doors, is panelled with fiddleback sycamore, charmingly treated and inlaid. The panelling in the drawing room is also fiddleback sycamore, of a soft grey tone, inlaid very delicately with holly wood. The colour scheme of this room, with the warm rose carpet and silk hangings, is very pleasing and homelike.

* * * *

En Suite and Special Staterooms.

In the special state and *en suite* rooms, of which there are 68, most of which have been fitted by Messrs. W. Turner Lord and Co., an interesting variety of effect has been obtained by a judicious choice

Fig. 108.—Panel in Children's Room.

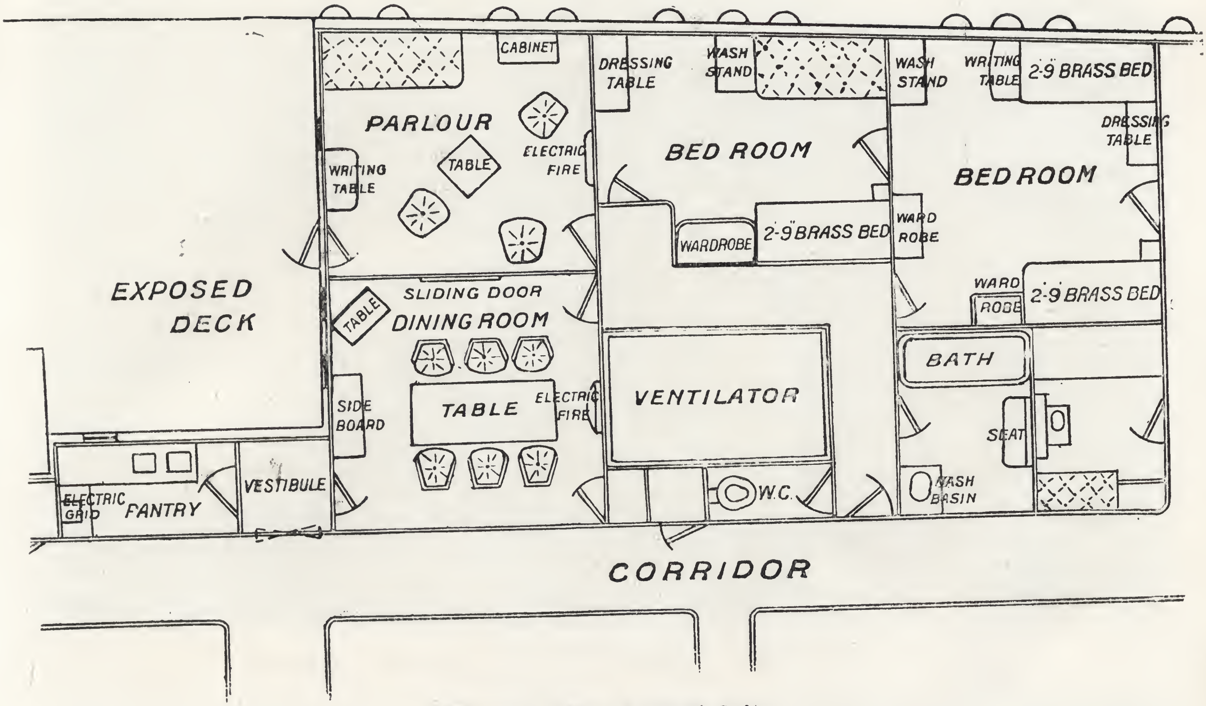


Fig. 109.—Plan of Regal Suite.

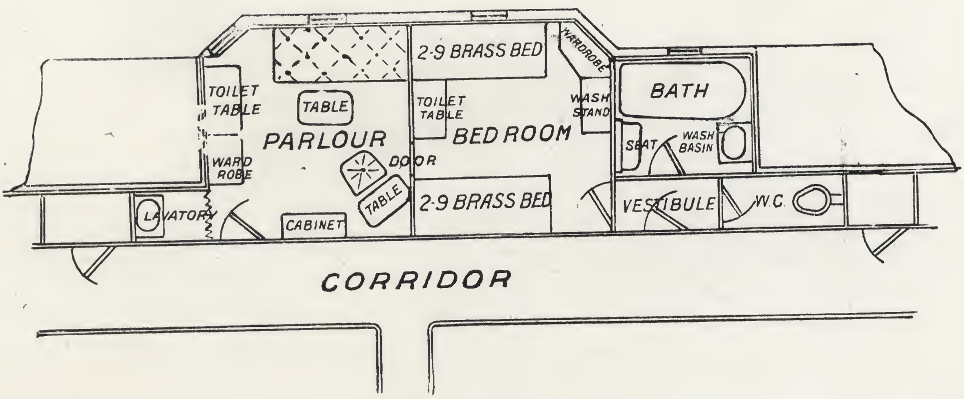


Fig. 110.—Plan of En Suite Rooms.

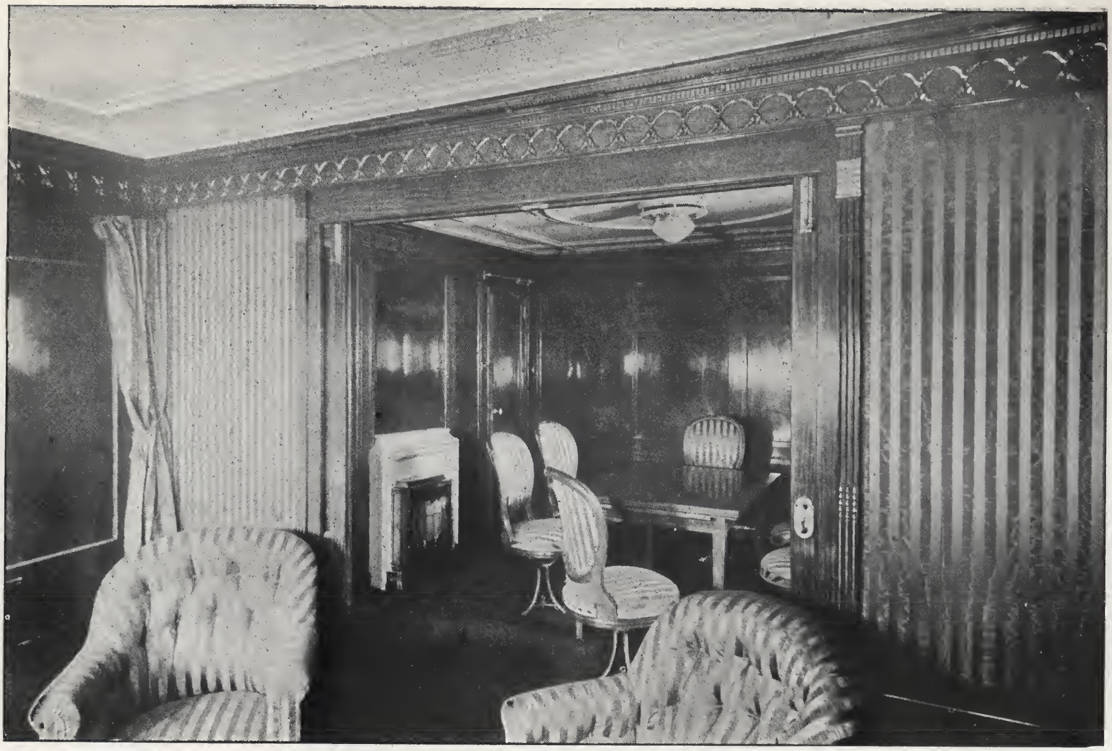


Fig. 111.—Dining Room of Regal Suite, from the Drawing Room.

Fig. 112.—Drawing Room of Regal Suite.

Fig. 113.—A Bedroom of Regal Suite.

Fig. 114.—Parlour of En Suite Rooms.

Fig. 115.—Sleeping Apartment of En Suite Rooms.

Fig. 116.—Suite of Rooms on Boat Deck.

FROM A PHOTO BY J. S. DODDS.

The First-class Library and Writing Room of the "Mauretania."

of woods and in the silk hangings and general colouring. One of the most effective of these rooms is the pear-tree room, with its inlay of holly wood, and cream and green upholstered surroundings. In the fiddleback sycamore room, the colouring is relieved with inlays of green wood in the pilasters and frieze panels, and the silk hangings and carpets have been carefully selected to be in harmony, the whole forming a very agreeable combination. with fine lace, laid on a contrasting colour and embroidered at the sides. The Sheraton, Chippendale and Adams rooms, fitted by Messrs. Robson & Sons, are revelations of clever workmanship and harmony of design, following in the truest spirit along the lines of the old masters of the cabinet-making craft. The material used is carefully selected timber, sawn from logs acquired thirty years ago, of beautiful figure.

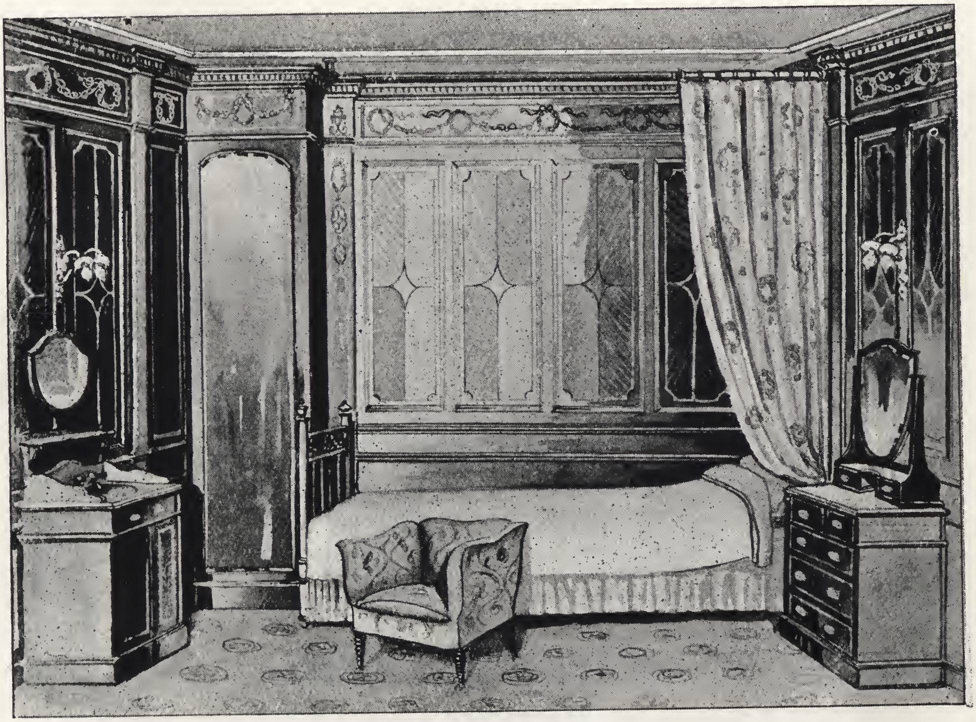


Fig. 117.—A Sheraton Room.

Another noticeable room is that in which the sycamore is of a soft grey colour, the relieving inlay being in holly and pear-tree. Mention might also be made of the several varieties of white rooms, with carved mouldings and mahogany furniture; or the rooms panelled in satinwood, inlaid with faded mahogany. Most of these rooms have recesses curtained off and fitted up with washstands in onyx marble. In many of the rooms the wall panels have been covered with cream silk, and in others a border of embroidery has been added, taking up the colours of inlays on the panelling and the carpets. Others, again, have the panels framed

First-class Staterooms.

The arrangement of the staterooms is indicated in Plates V. and VI. One hundred and nine first-class passengers are accommodated in staterooms on the main deck, within convenient reach of the staircases and lifts. These staterooms, which are very large in size, are arranged for one, two or three passengers, the number of berths fitted for the latter number being comparatively few. Most of the first-class staterooms on the main and other decks are in white, the "Satinette" white enamel of Messrs. Pinchin, Johnson & Co., Limited, of London, having

been used exclusively for these rooms and also for some of the principal corridors. The mahogany furniture of the staterooms forms a pleasing contrast to the panelling. The floors are covered with crimson Brussels carpet, the sofas are upholstered with pink or red tapestry, the door curtains are crimson, and the window curtains are in cream chalis with a floral design on the edge.

On the upper deck is fitted a large number of superior cabins, the distinguishing feature of which is that each has its own lavatory, recessed into the bulkhead and curtained off from the main portion of the apartment; see Fig. 119. This lavatory is fitted with dressing mirror, sponge and soap trays and all other accessories, and a hot and cold water service is laid on. These rooms are also panelled in white, but the furniture is executed in a variety of woods, such as satinwood, oak, mahogany and walnut. A brass bedstead, of special design, is fitted in each room. Above the bed is a folding berth, which can be hinged back when not in use. A sofa is provided on the opposite side of the room near the wardrobe, and a handsome dressing and writing table combined has also been added. In addition to these special rooms, a number of more ordinary staterooms are provided on the upper deck, fitted to accommodate one, two or three passengers. They are furnished with folding lavatories, dressing tables, sofas and wardrobes, the furniture and fittings being generally similar to those in the rooms on the main deck.

On the promenade and boat decks, in addition to the Adams, Sheraton and Chippendale rooms to which reference has already been made, a large number of staterooms for one and two persons are provided, and a few three-berth rooms. No stateroom on the boat deck is intended to accommodate more than two passengers.

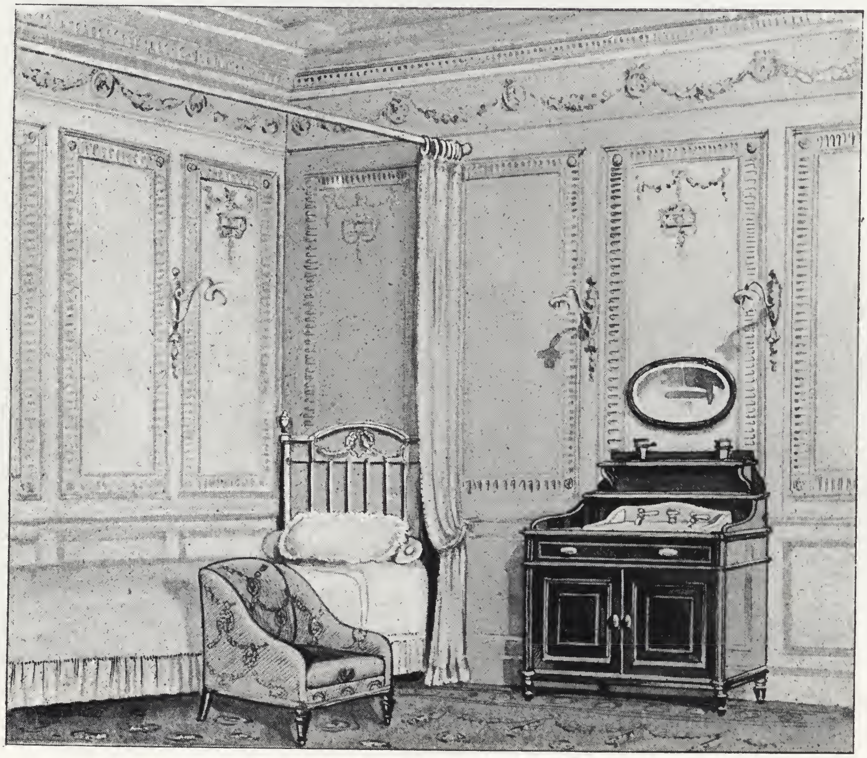


Fig. 118.—An Adams Room.

* * * *

Second-class Accommodation.

LIKE the first-class accommodation, the public rooms and staterooms for second-class passengers extend from the main to the

boat decks, but are situated at the after end of the vessel. Only in magnificence and not in comfort does the first-class accommodation surpass the second-class, the same care and attention having been exercised in the equipment of both classes, and indeed a passenger on first going on board might well be excused for mistaking the second-class public rooms and staterooms for the first-class. Only a few years ago such accommodation would have been considered fully worthy of first-class passengers, and if one feature more than another will make the *Mauretania* popular with Atlantic travellers it will be the beauty and comfort of this section of the accommodation. In catering for this class of passenger, the Cunard Company may fairly claim to lead the way among the great steamship lines plying between the Old and the New Worlds. The second-class staterooms are all on the main, upper and shelter decks, while the public rooms are on the promenade and boat decks.

Second-class Grand Entrances and Staircases.

THE second-class grand entrances extend from the main to the boat deck, and are in specially selected teak, beautifully marked. The floors throughout are laid with black and white rubber tiling in a simple design. The grand and auxiliary staircases are also in teak, similar to the entrances, and ascend from the main to the boat deck, thus giving access to all the second-class quarters.

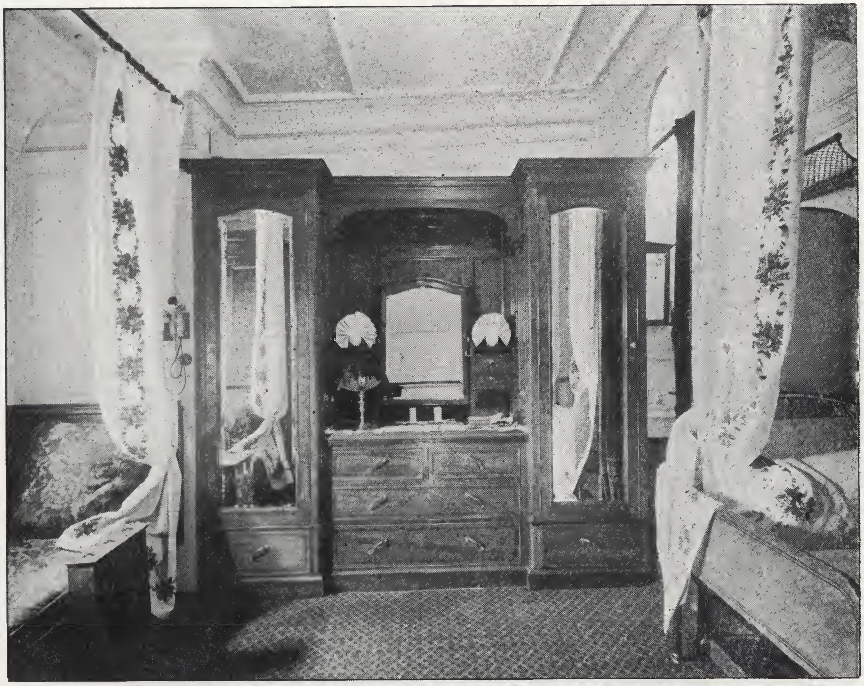


Fig. 119.—Special First-class Stateroom on Upper Deck.

Second-class Dining Saloon.

THE second-class dining saloon, which opens off the grand entrance, is 61 feet long and the full width of the ship, with a height of 10 feet. The style of the room is Georgian, with carved cornice. The design is executed in oak, and the floor is laid with parquetry to harmonise with the walls. Above the centre of the room is a large octagonal opening, communicating with the grand entrance on the shelter deck

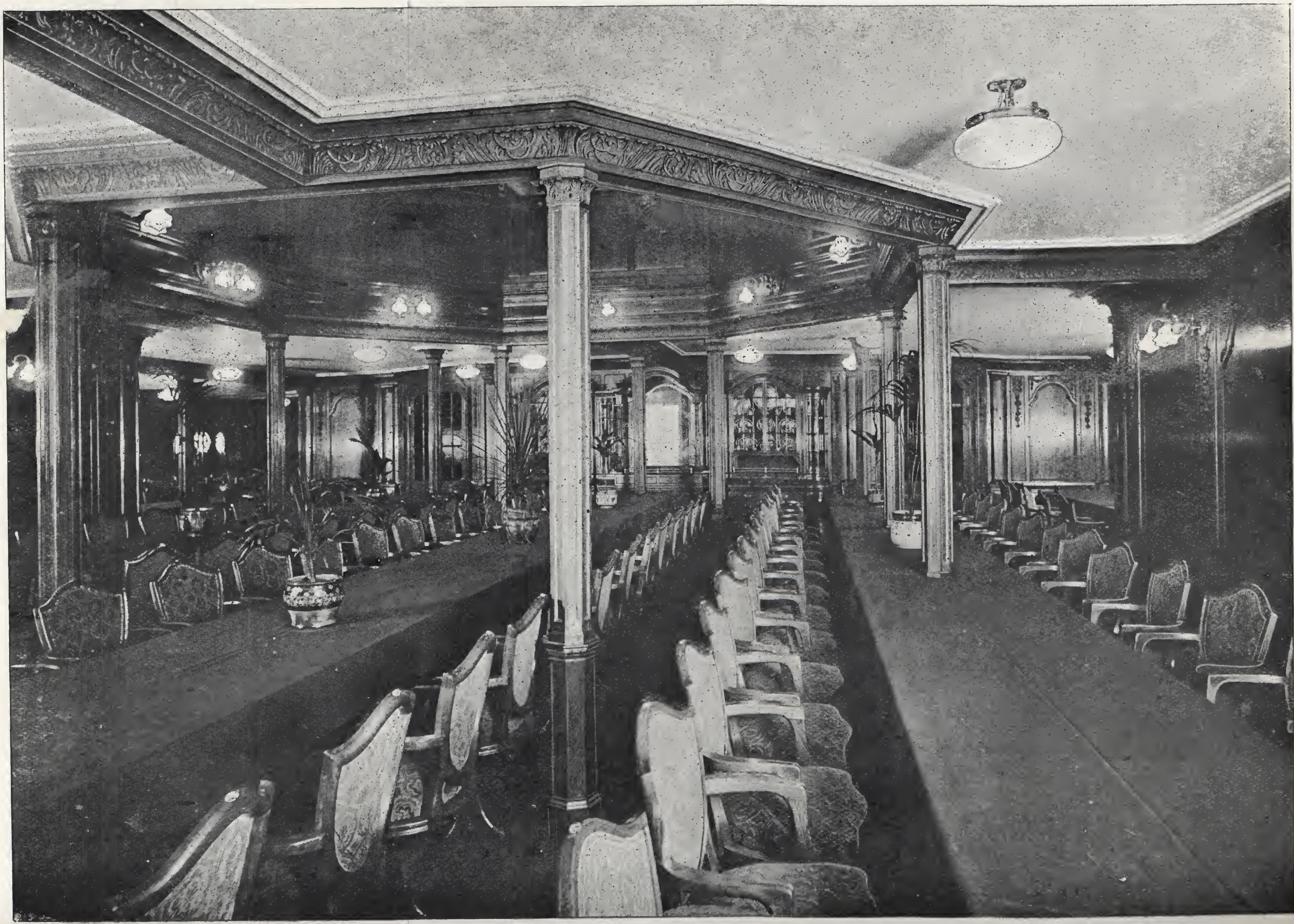


Fig. 120.—Second-class Dining Saloon.

above, and forming the dome of the dining saloon. This dome has a total height from the floor of the dining saloon of 19 feet. An electrolier, of handsome design (illustrated in "Electrical Installation"), is suspended from the centre of the dome, and is surrounded by smaller electric lights. A massive carved oak sideboard is a prominent feature at the after end of this apartment, immediately opposite being the piano. The tables, at which 250 persons can be seated, are also in oak. Brussels carpet runners of a bottle green are laid on the polished floor between the tables, and the revolving chairs are upholstered in frieze velvet of the same colour. The windows round the sides of the room are arranged in pairs, and the room generally has a light and airy appearance, which is considerably enhanced by the lofty dome.

Fig. 121.—Bay in Second-class Dining Saloon.

* * * *

Second-Class Drawing Room.

THE second-class drawing room is situated on the promenade deck. Fitted up in a variety of maple woods with gold decorations, this apartment is in style a free translation of the Louis XVI. period. A dome of obscured glass with gilded metal framework surmounts the room, and in the walls are large square windows. The sofa seats and chairs are upholstered in crimson frieze velvet, and the window curtains are of a tint to harmonise. The carpet is of crimson Brussels, and the small tables scattered about the room give an appearance of ease and comfort. The piano, designed to suit the room, is in maple, with gold decorations. As a quiet retreat while at sea, this room will be exceedingly popular with lady passengers.

* * * *

Second-class Smoking Room.

THE second-class smoking room, 51ft. 6in. long by 40ft. wide, with a height of 8ft. 6in., opens aft from the grand entrance on the promenade deck, and is late Georgian in style. This apartment is fitted up in mahogany, inlaid with English boxwood and Burr mahogany, giving a very artistic effect. The upholstery of the chairs and sofa seats

Fig. 122.—Second-class Smoking Room.

Fig. 123.—Second-class Lounge.

is in dark blue velvet pile morquette. The floor is covered with inlaid linoleum, with dark blue Brussels carpet runners. The dome overhead is generally similar to that in the second-class drawing room, but the windows are larger and arranged in pairs.

* * * *

Second-class Lounge.

THE grand entrance on the boat deck is extended to form the second-class lounge. Access to the open-air promenade is obtained through a handsome vestibule on each side of the apartment. Teak has been used throughout, to correspond with the grand staircases which terminate on this deck. The windows in this apartment are unique in ship construction, each being divided into three portions. The two outer portions are rectangular, and the centre and larger portion has a graceful radius top. Blue carpet runners are laid on the wood deck, and the upholstery is in morquette of a tint to match the carpets.

Second-class Staterooms.

SEVENTY staterooms, each accommodating two or four passengers, are situate on the main deck. As in most of the first-class cabins, these rooms are panelled in white, with mahogany furniture. Sofas, wardrobes and lavatory compactums are fitted. On the upper deck, 39 staterooms have been fitted; and on the shelter deck, some special second-class cabins are provided, which, with their large square windows and other fittings, are only slightly inferior to many of the first-class staterooms. The upholstery throughout all the second-class staterooms is in dark morquette, the carpets being of crimson Brussels. The window and berth curtains are in blue chalis, and the door curtains in crimson chenille.

Fig. 124.—Second-class Stateroom.

* * * *

Third-class Accommodation.

AT the forward end of the vessel on the lower, main, upper and shelter decks, is the third-class passenger accommodation. Two main staircases extend from the main to

FROM A PHOTO BY J. S. DODDS.

The Second-class Drawing Room of the "Mauretania."

the upper deck, one giving direct access to the dining saloon on the upper deck. This saloon is very large, being 84 feet long and the full width of the ship, and its height (10 feet) gives a light and airy appearance. Three hundred and thirty persons can be accommodated at one sitting, revolving chairs being provided for this purpose. The room is panelled out in best polished ash with teak mouldings, and the floor is covered with corticine. A piano is placed at the forward end of the saloon; and the side-

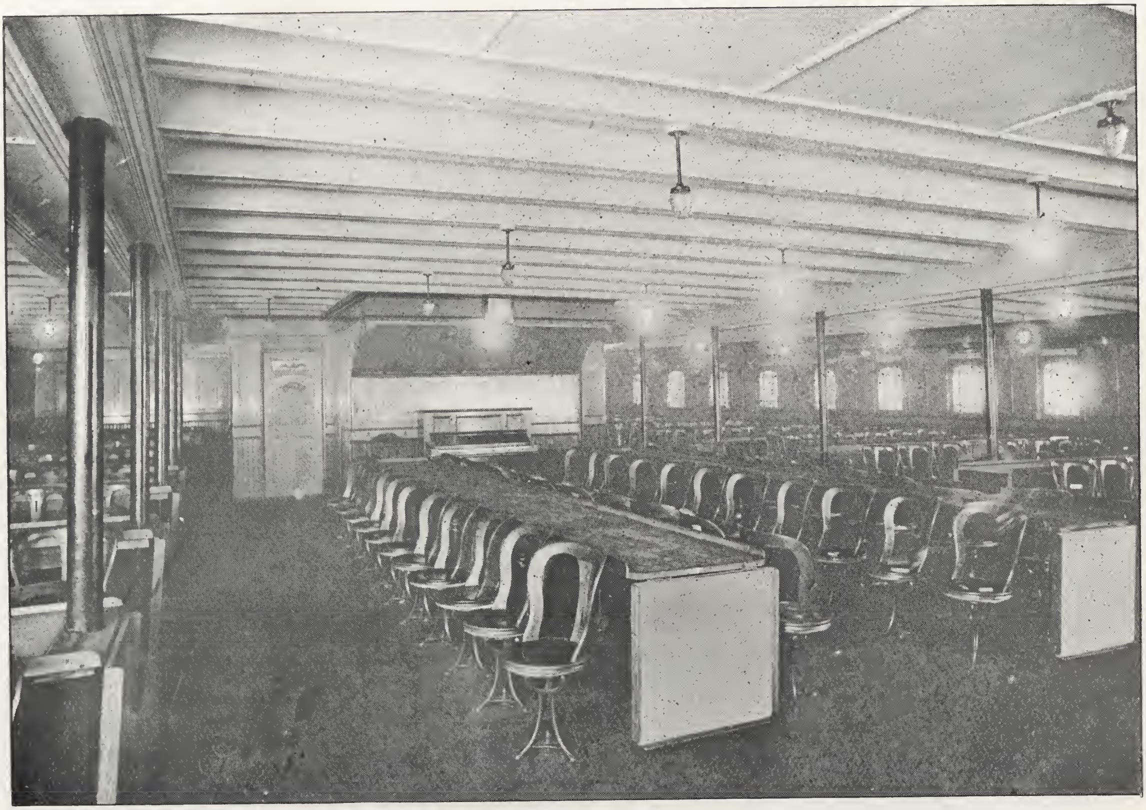


Fig. 125.—Third-class Dining Saloon.

lights are screened by sliding sashes, fitted with coloured obscure glass. The smoking room and ladies' room, two large apartments, are situated on the shelter deck. The smoking room, on the port side, is 50 feet long, 24 feet wide, and over 9 feet high. The ladies' room, on the starboard side, is 50 feet long, 20 feet wide, and the same height as the smoking room. Both rooms are panelled out in polished ash with teak mouldings, are provided with revolving chairs, and are generally similar to the dining saloon, the floors being covered with corticine. The sleeping accommodation for third-class passengers is on the lower and main decks, a large number of the rooms on the lower deck being portable.

* * * *

Promenade Space.

First-class passengers have an open-air promenade space 450 feet long by 18 feet wide on the boat deck, on each side of the vessel. On the promenade deck, the space available for outdoor exercise is 310 feet long by 18 feet wide on each side of the vessel. The space on the promenade deck, although open at the sides, is protected above, so that it can be used in wet weather. It will be seen, therefore, that before a passenger has walked three times round the first-class promenade space he will have covered a mile. The second-class passengers are provided with open-air space on the boat, promenade and shelter decks, the space on the two last-named being covered overhead. In

Fig. 126.—First-class Promenade Deck, looking aft.

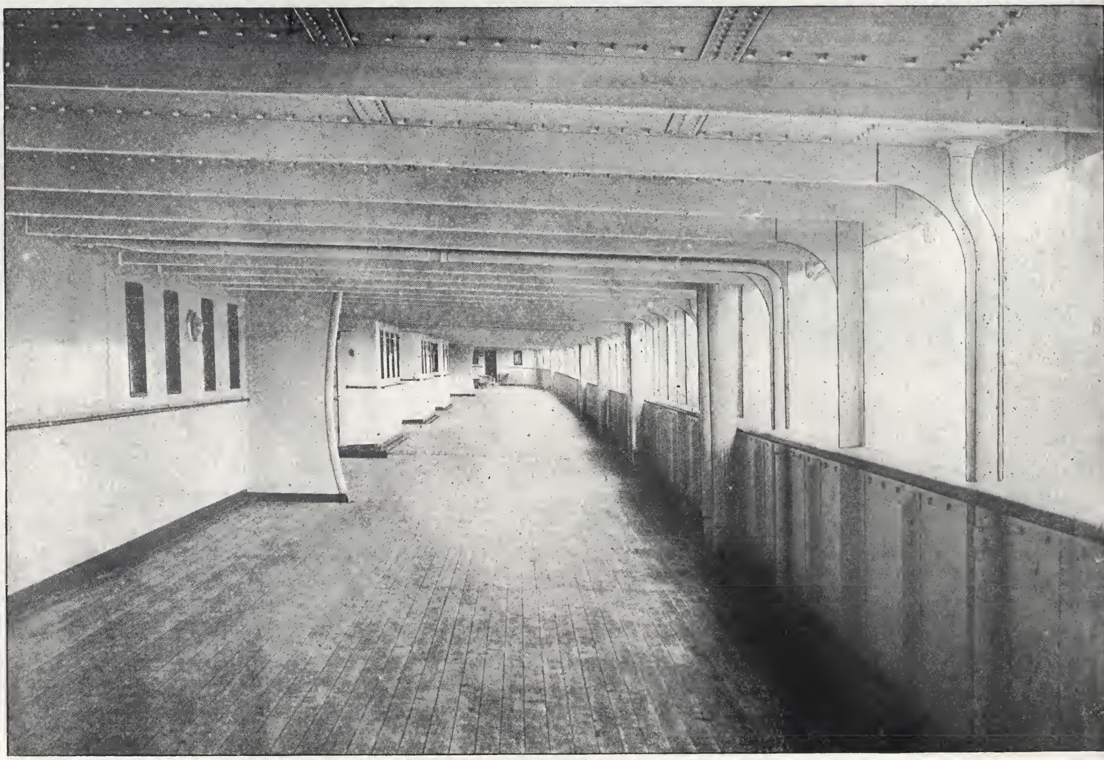


Fig. 127.—First-class Promenade Deck, looking forward.

Fig. 128.--Second-class Promenade (Boat Deck, looking forward).

all, they have 16,500 square feet of deck space for walking and other exercise. Third-class passengers have a length of 320 feet of space on the shelter deck on each side of the ship, with a width of 16 feet. This space is entirely covered overhead, and there are open rails at each side for a distance of over 180 feet.

Fig. 129.—First-class Promenade (Boat Deck, looking aft).

Ventilation and Heating.

The warming, cooling and ventilation of the whole of the accommodation for passengers, officers and crew has been carried out upon the thermotank system, by the Thermotank Ventilating Company, Glasgow.

The thermotanks are designed to change the air in any of the compartments to which they are connected six or eight times per hour, either by exhaust or supply, and are capable of maintaining a temperature of at least 65 degrees Fah., under the coldest of weather conditions. The system also ensures a continuous supply of fresh air to all the living quarters of the ship, which can be warmed to any required temperature.

There are in all 53 thermotanks in the installation, 29 of which are used for supplying the public rooms and staterooms in the first-class, 9 for the second-class, and 15 for the third-class accommodation, including officers' and crew's quarters. The various thermotanks are connected in pairs, so that should one break down a continuous supply of fresh air can be obtained from the other thermotank.

The thermotanks supplying the public rooms or staterooms in the first-class accommodation are mostly arranged on the sun deck, as in this position they are kept clear of the promenade space below. The thermotanks arranged round the funnel casings are all of the bottom-suction type, that is to say, a fresh air supply is taken from one of the promenade decks below. This has been done in order to prevent any coal dust or unpleasant odour from the galleys and lavatories being carried down from the funnel deck.

Considerable ingenuity has been shown in the selection of a space for admitting fresh air to the forward compartments of the ship. No openings or cowl-heads are taken through the decks forward of the bridge house on account of the water that might be shipped in bad weather; so that in order to ensure a supply of fresh air being carried forward to the various thermotanks below the shelter deck, a trunk is led to the after end of the flying bridge, with specially arranged doors and openings to prevent the admission of rain or spray.

The general arrangement drawings on page 125 illustrate the working of the thermotanks, as follows:—

Fig. 130 shows the working of the bottom-suction deck type thermotanks, when supplying fresh, warmed or cooled air to the various compartments. Fig. 131 shows the working of 'tween deck type thermotanks when exhausting foul air from the various compartments to which the trunking is connected, and deck top-suction thermotanks are shown by Fig. 132.

The thermotank generally consists of an electric motor driving a fan, which discharges air outside and then inside a tube heater. The air passing through the tubes comes in contact with the hot or cold surface and thence to the main distributing trunks. It will be noted that there are two valves for controlling the passage of the air, and also one for regulating the temperature. The heat is obtained in the heater from steam at a pressure of about 30

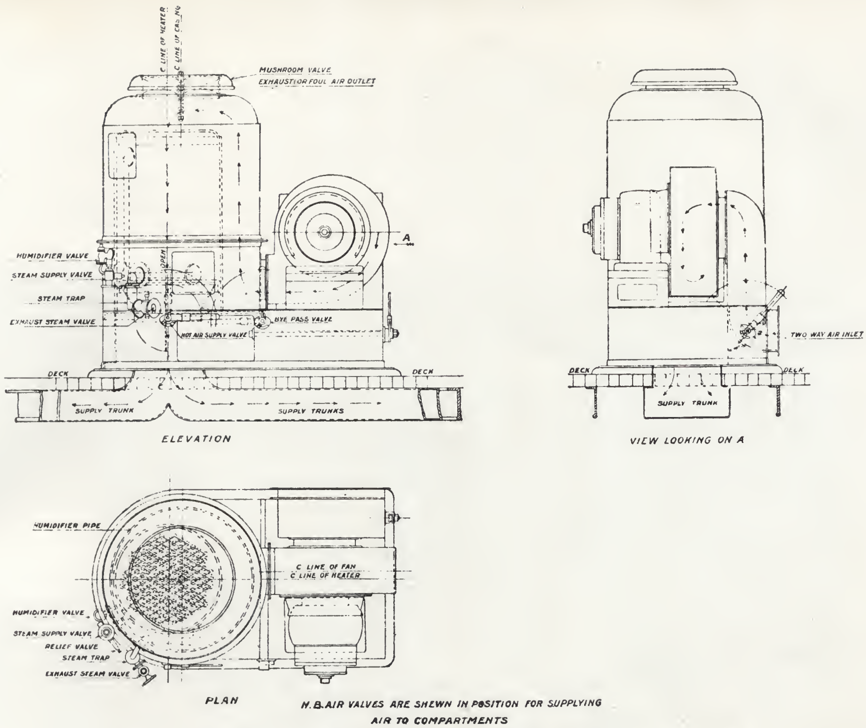


Fig. 130.—Thermotank of Deck Type—Bottom-suction.

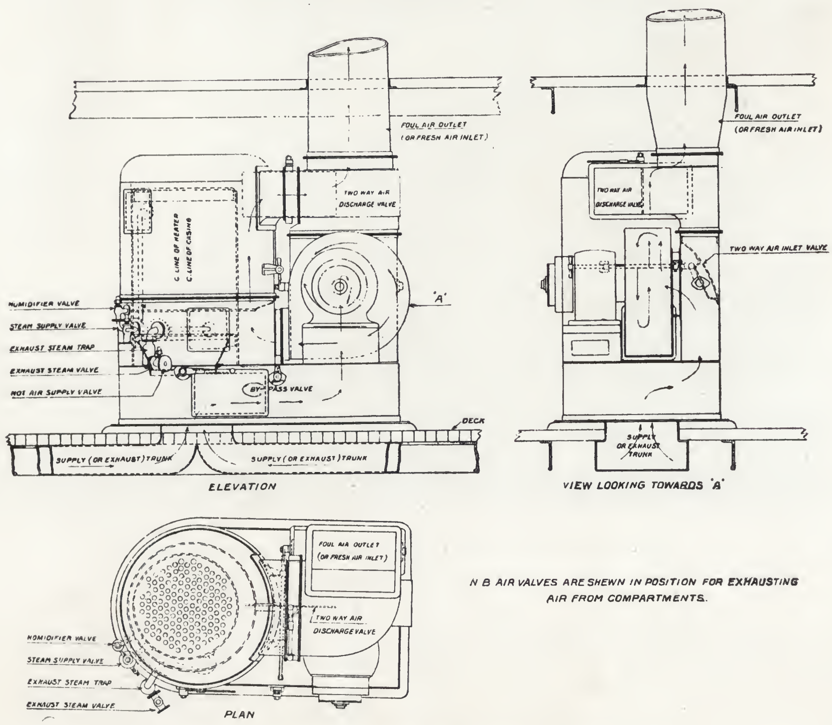


Fig. 131.—Thermotank of 'Tween Deck Type.

lbs.; and in addition to being warmed, the air is also humidified by means of a steam spray obtained from a copper tube surrounding the heater, and designed to give any desired degree of humidity. The air after leaving the thermotanks is carried through main distributing trunks, which in most cases are taken down the made of galvanized sheet iron, and has been supplied by Messrs. Brown & Hood, of Wallsend. The total length of trunking amounts to no less than 17,000 feet, or about $3\frac{1}{4}$ miles, and includes over 5,000 bends, tee-pieces, etc. A separate louvre is taken to each stateroom, which can be regulated by means of a suitable

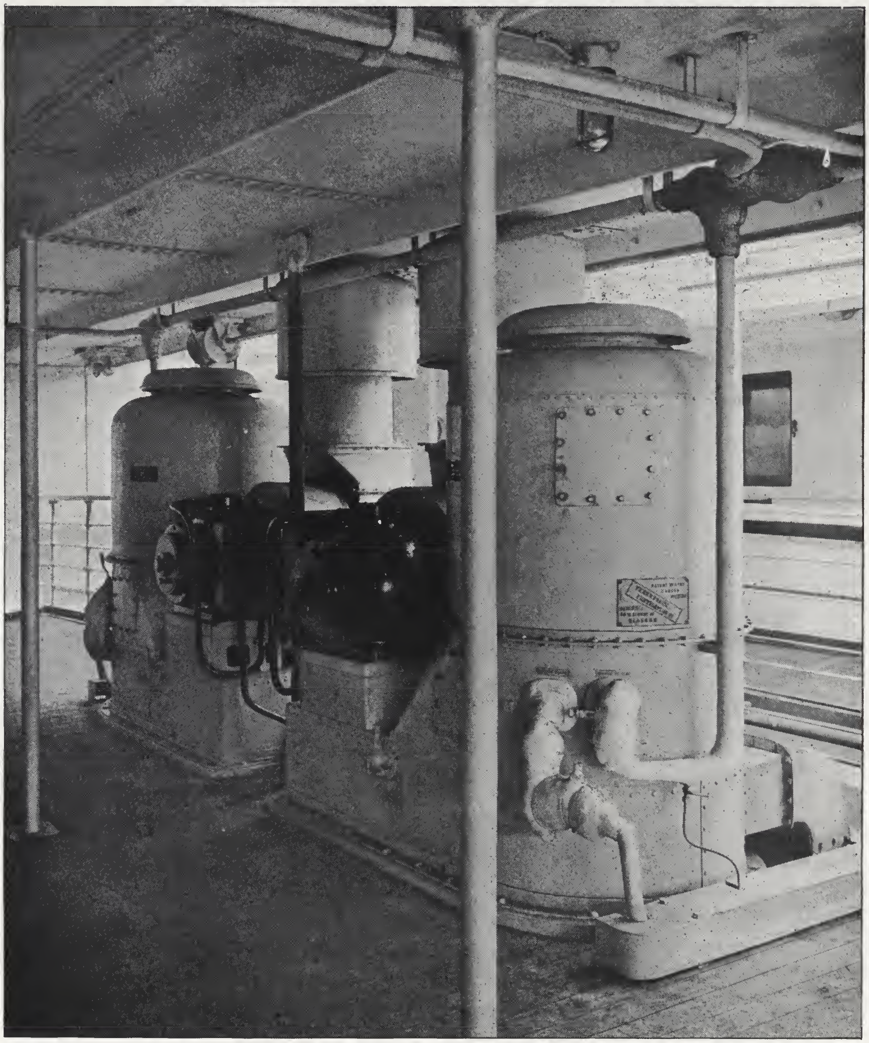


Photo by] [*Bedford Lemere & Co.*

Fig. 132.—Two Deck Top-suction Thermotanks on Second-class Promenade Deck.

light and air spaces, and from thence are connected to athwartship trunks carried between the beams. From these athwartship trunks, branches are taken fore and aft below the beams, and in the first and second-class quarters are boxed in out of sight. The trunking is all valve operated from a handle on the side of the cabin.

Tests have been carried out to compare the efficiency of the thermotank system with ordinary steam heaters; and it has been found that while the steam-heated system took

three hours, the thermotank only required 15 minutes to heat a given space to the same temperature. The consumption of steam is small, as all the heat is abstracted, only water being drained off to the feed tank. This system also overcomes most of the defects of the radiator system, where there is an unequal distribution of heat, since the temperature nearest to the heaters may be too high and yet too low some distance away. There is no possibility of a leakage at the joints of pipes causing sweating of decks and damage to fittings, apart from the expense in maintenance thus involved. No condensation takes place in the pipes, involving the starting of joints, and the setting up of noise. There is no risk of accidental burns from exposed hot pipes in the living quarters of the ship, and no waste of room owing to the space occupied by heaters and pipes. No over-drying of the air takes place, with its deleterious effect on the health of the occupants.

In addition to the thermotanks, the ventilation is further augmented by means of 14 powerful exhaust fans, also supplied by the Thermotank Company. These fans are connected by means of trunks respectively to all the galleys, pantries, bathrooms and lavatories, and are of sufficient capacity to change the air in the above-mentioned compartments at least 15 times per hour; so that no matter what conditions of weather exist, there is always a flow of air towards these compartments, thus preventing any unpleasant smells permeating the living rooms.

* * * *

Sidelights and Windows.

In addition to the artificial system of ventilation, the sidelights and windows provide natural ventilation in a very effective manner. Round sidelights are adopted in all cases where the lights penetrate the ship's side, but in the houses above the shelter deck rectangular windows have been fitted, as they will not be exposed to the force of breaking seas and openings in the house sides can be more easily compensated for. The provision of windows, besides increasing the efficiency of the lighting and ventilation, greatly adds to the appearance of the ship. A large number of the round windows below the shelter deck are of the Utley ventilating pattern In the Utley light, when the glass is closed, air is still ad-

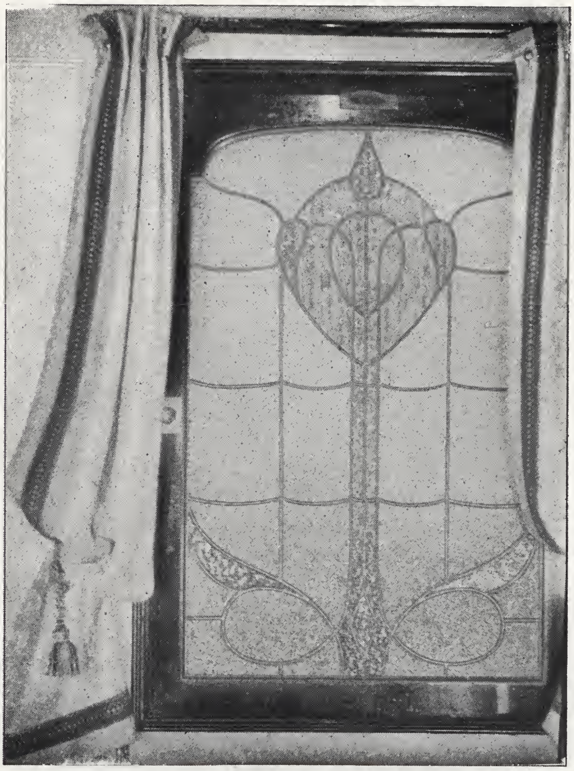


Fig. 133.—Deckhouse Window showing obscured glass shutter.

mitted through a chamber, for which a louvre is provided just above the sidelight. Inside the chamber is a float, which closes the opening into the cabin should any water find its way into the chamber, thus preventing the water penetrating inside the vessel. The windows in the first and second-class public rooms have been supplied by Messrs. J. Stone & Co., Deptford, and their appearance may be clearly seen in the various illustrations of the public rooms. Most of them are sliding windows.

The windows in the first-class staterooms upon the boat and promenade decks are of an entirely new type, specially designed for the vessel in the Joinery Department at the Wallsend Shipyard. They are constructed to withstand the fiercest gale and at the same time to appear part of the delicate interior furniture, each window corresponding in style to the room in which it is placed. These windows are arranged to give permanent ventilation while preventing a direct current of air on to the

passenger, and they allow extra ventilation to be obtained if desired. The adjustable screens are provided as shown in Figs. 133 and 134. One screen is of clear glass, the second is of wood lattice which enables a current of fresh air to pass into the room and at the same time secures privacy for the occupant, while the third is of obscured glass and permits the passage of light without the interior being visible from the outside.

* * * *

Passenger Elevators. As the first-class passenger accommodation is situated on five decks, a considerable amount of exertion is required to go up the staircase from the lowest to the uppermost deck. For the comfort of the passengers, therefore, two electrically-driven passenger elevators have been fitted at the main stairway by Messrs. R. Waygood & Co., Limited, of London. These lifts have a vertical travel of 37ft. 6in., extending from the main to the boat decks, and are arranged as shown in Fig. 135. Two vertical steel guide rods are provided for each car, and special safety apparatus is fitted in the car, which will come into action should the lifting ropes fail. Each car is worked by steel ropes, passing over a pulley immediately above, and thence to the winding drum of the lifting motor, which is placed at the end of the lounge skylight on the sun deck. From the winding drum the ropes pass over a second pulley to the counter-balance weight, which travels in a vertical trunkway, as shown in the illustration Fig. 135. Two ropes, of best steel wire, are attached to each car and winding drum, and two independent ropes are connected to the counter-balance weights and also to the drum to ensure a positive drive. The winding gear is of the worm-and-wheel type. Right and left hand spiral grooves are provided in the winding drum, in which the lifting ropes coil. The brake gear is actuated by a magnet in such a manner that it is applied automatically when the current is cut off by the control and released when the current is switched on.

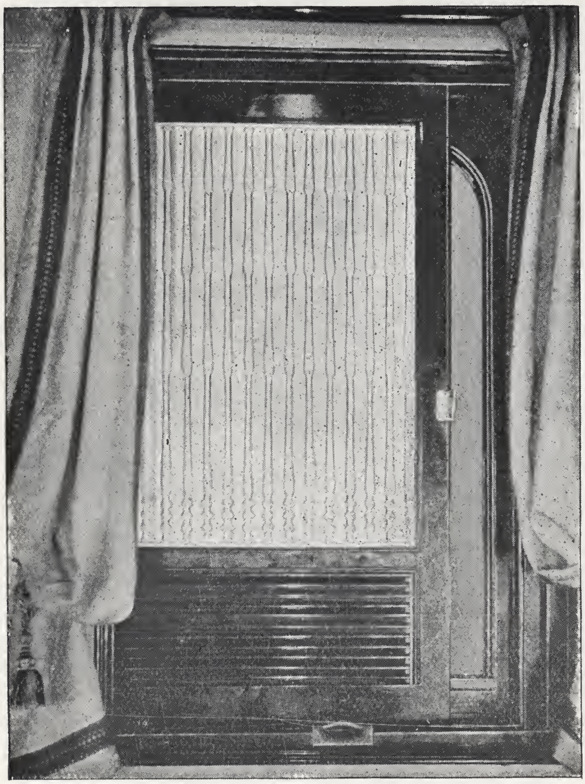


Fig. 134.—Deckhouse Window showing clear and lattice shutters.

The controller is magnetically operated and is worked from the car by means of a special car switch having an "up," "down" and "stop" position. The "up" and "down" circuit-breakers are mounted on the main controller panel, each being operated by a magnet and a rheostat and provided with air retardation. The main resistance is cut out by the rheostat in sixteen steps. The car switches are provided with movable self-centering handles, so that in the event of the attendant releasing the handle for any purpose, it at once flies to the "off" position, cutting off the controller and stopping the lift. A special automatic cut-off switch is provided, positively driven from the drum shaft of the motor, which will work the controller and stop the lift when approaching the top and bottom levels should the attendant omit to switch off the current. In the event of the lifting ropes becoming slack through any cause, the current is cut off by Waygood's patent slack cable switch and the brakes applied at the same instant, so that the lift is stopped at once.

The entrance doors are so arranged that they can be opened only when the car is opposite, and they cannot be closed until the car is moved away. The cars may be called from any deck, an electric bell and indicator being provided in each car.

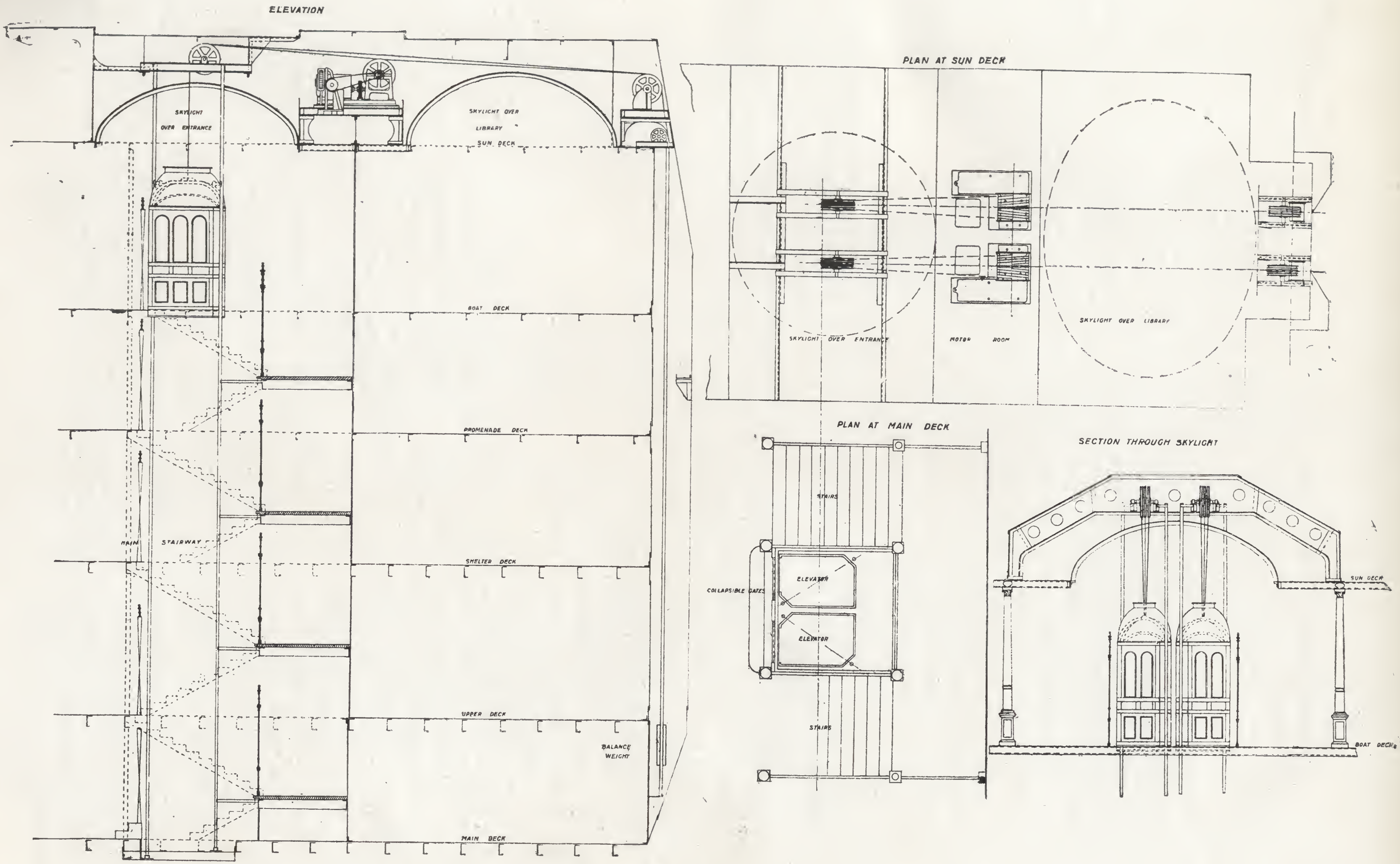


Fig. 135.—Passenger Elevators.

Culinary Department.

The galleys, pantries, bakery, confectionery room and knife-cleaning room for the first and second-class accommodation are the full width of the ship and extend for a distance of 130 feet. Combined, it is claimed that they form the largest kitchen afloat, and they are fitted in a manner to satisfy the requirements of the most exacting *chef*. Situated on the upper deck between the first and second-class dining saloons, a handy service is ensured to both; while for serving the first-class upper dining saloon or restaurant, a pantry is provided on the shelter deck just over the main pantry. Separate deck pantries are also provided at all the public rooms and regal suites. All the fittings for the culinary department have been supplied by the well-known firm of Henry Wilson & Co., Ltd., of Liverpool, and some idea of the elaborate arrangements pertaining to a large liner may be gained from the plan view of the main galleys shown in Fig. 136. Electricity has been largely employed for driving the various machinery.

The main range is placed in the centre of the kitchen and has a total frontage of 70 feet. It has no less than 14 ovens and hot closets, is fitted with bain maries and other contrivances, and stands under an electrically lighted canopy, the latter carrying racks for pans, *entrée* dishes, etc. Although so large, the range is not used for roasting meat, this operation being performed in one of Wilson's largest patent roasters, the spits being driven by an electric motor. A similar roaster, of somewhat smaller size, has been reserved for cooking game. Three large grills are provided, each lined with white enamelled plates and fitted with silver grids to prevent disfigurement of the food. Twelve steam ovens have been fitted, supplied with fine steam from the evaporators, which is a great improvement upon the practice of taking steam from the main boilers often impregnated with grease and dirt. There are also electrically-driven meat-slicing machines of the well-known Berkell make and electric triturating machines and whisks, etc.

The baker's and confectioner's shops are excellently arranged, and fitted with four large ovens with independent furnaces, a baker's range for syrups, &c., steam ovens for puddings, two large bread provers, and a dough-mixing machine, the latter being one of the largest afloat. The confectioner's shop is well supplied with whisks and cake-making machines, an ice-cream machine, electric hot plates and refrigerators, and indeed everything most useful in this department, including a long marble-topped table. One has only to consider what it means to make bread and confectionery for over 3,000 persons to get some idea of the work that has to be accomplished in these departments.

The pantries and serving rooms have also received very close attention, being fitted with magnificent carving tables, bain maries, hot closets, Cornhill coffee, milk and hot-water apparatus, automatic egg boilers, Berkell's sandwich-making machines, etc., while there is a separate still room for serving salads, ices, cheese, fruit, etc. All the principal pantries have sculleries fitted with "vortex" dish-washing machines, for the rapid handling of dirty crockery, silver, etc. Four electrically-driven knife-cleaning machines are provided in the room specially set apart for that purpose. Lifts are arranged from the galley to the engineers' and officers' mess-rooms on the deck above, and to the storerooms below.

The third-class passengers have their own galley upon the shelter deck forward (see Plate VI.). This apartment is 48 feet long, by 28 feet wide, and is fitted with an immense cooking range built in two tiers, steam boilers, vegetable cookers, etc., etc. The galley is connected by means of a lift and a staircase with the third-class pantry below.

* * * *

Service of Plate.

The service of plate, supplied by Messrs. Elkington & Co., Limited, of London, embraces more than 3,000 pieces of what is briefly described by the makers as "hollow ware"—tea and coffee pots, sugar basins, cream ewers, entrée dishes, vegetable dishes, cruet frames, butter coolers, sauce boats, soup tureens, soufflé dishes, and many other accessories, including nearly 16,000 spoons and forks. The general design adopted in the service embodies the distinctive features of several well-known styles, and follows what is now recognised as the "Cunard" standard. Utility has been, of course, the primary consideration, but decoration has not been neglected; and it is a most successful feature in the fruit dishes, which are heavily chased and lined with gold. Where a simpler ornament has been possible, it takes the appropriate form of a cable mount. The plant as a whole, decorated and plain, will be distinctly pleasing to the eye of the most fastidious ocean traveller.

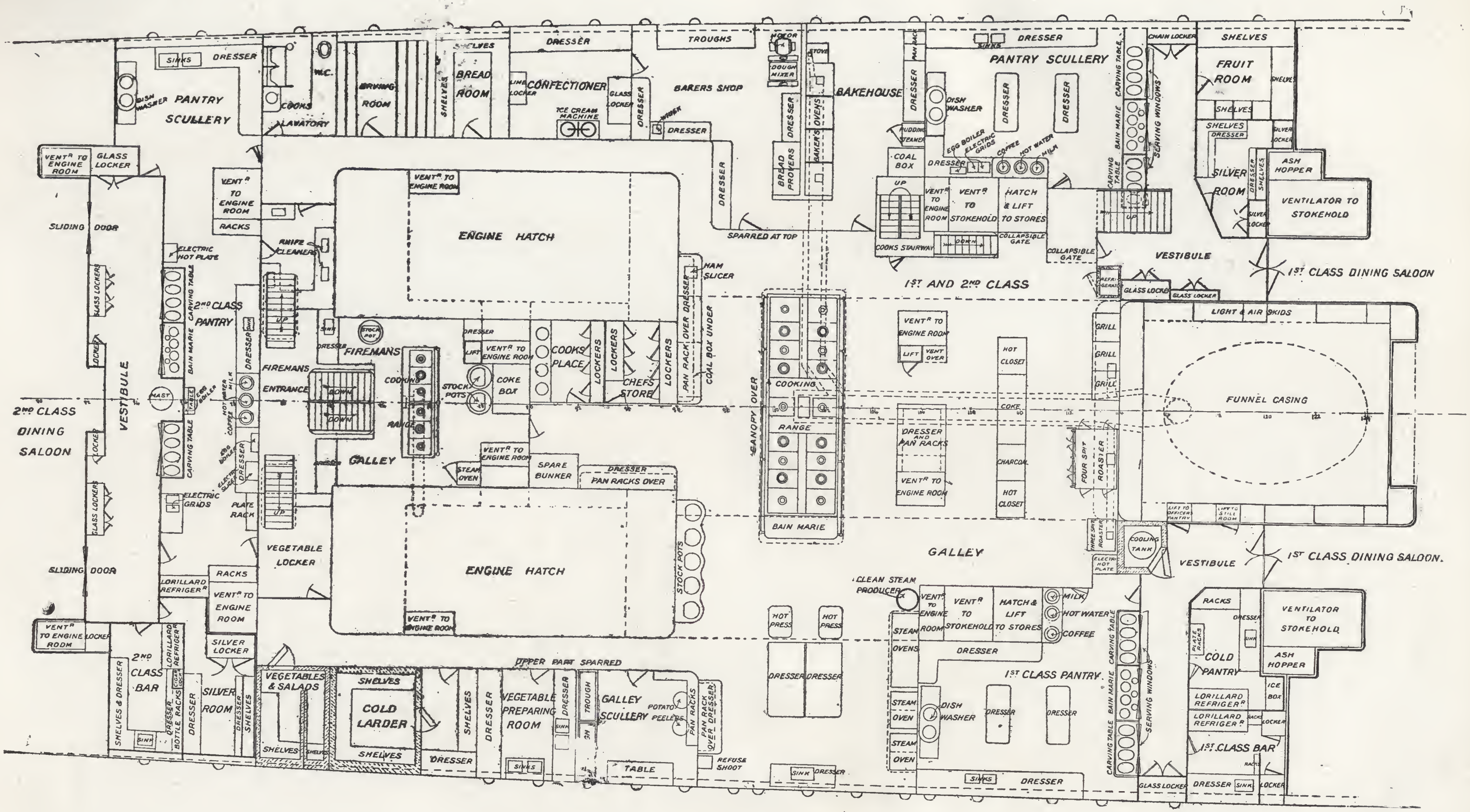


Fig. 136.—First and Second-class Galley.

Water Services.

THE piping arrangements for the various water services have entailed an enormous amount of work, and it is practically impossible to estimate the quantity of piping which has been used. The various services consist of the fire and wash-deck service, which is in duplicate, one service being carried on each side of the vessel, hot and cold fresh-water services to all the culinary departments; hot and cold condensed-water services to all basins and lavatories throughout the ship; cold salt-water sanitary service with connections to all baths; hot salt-water service to all baths; and an iced-water service to all pantries and service rooms. Tanks for maintaining all these services, with the exception of the fire and wash-deck service and the iced-water service, are placed upon the sun deck. All the plumbing work has been carried out by the plumbing department at the Wallsend Shipyard, which deserves great credit for the way in which it has coped with a necessarily complex piping system.

* * * *

Sanitary Outfit.

THE lavatory accommodation for all classes may be termed truly magnificent and has been carried out in a manner not previously attempted on board ship, the whole of the fittings having been specially designed and supplied by Messrs. Doulton & Co., of Lambeth, London, and Paisley, whose reputation for this class of work is probably unrivalled.

All piping is in white metal, and in the first-class staterooms and regal suites the whole of the metal work is heavily silver-plated.

The baths are in all cases made of cast iron, white porcelain enamelled inside and outside. This gives a perfectly smooth surface and is in every way equal to fireclay, while the appearance is much lighter and more elegant. The feet of the baths are bolted to the deck, to prevent movement. In the first-class a skeleton spray is fitted to the end of the baths, combined with shower and valve for plunge. The valves used are of the Doulton patent anti-scalding mixing type, by which the water can be regulated to any temperature by a slight turn of the lever handle. Each valve has a bold dial face and is marked hot, cold, and tepid, and the user simply turns the pointer on the lever to whatever temperature is required. In addition, a thermometer is fixed to each valve, so that it can be seen at once exactly what the temperature is. Each bath is placed on a veined marble dished base. The shower itself is made in white earthenware, perforated, and it can be readily removed for cleansing. There are also six special combined skeleton showers and needle sprays, so that passengers can have a spray bath if the plunge is not required. The second-class baths are generally similar, but have no needle arrangement as in the first-class. Shower baths are provided for the crew.

The lavatory basins throughout are large. In the first-class and regal suite rooms they are ornamented with gold lines, and are provided with a special concealed standing waste, arranged so as to be easily removed for cleansing. The marble used is in great variety, from St. Anne's to statuary, onyx and other specially selected kinds. Throughout the ship the valves are non-concussive, thus preventing the objectionable noise resulting from concussion in pipes when self-closing valves are used, and obviating the risk of serious damage to the pipes. All supply and waste pipes where brought through the deck are arranged with connections so that they can be easily disconnected if necessary.

Fig. 137.—A First-class Bath.

The closets in the first-class accommodation are made in best white earthenware with gold line decoration, and are pedestal in form. A special feature is an arrangement attached to the outlet, in the form of a metal box with balanced storm valve, so arranged as to prevent any back flow of water, while at the same time it does not impede the flush. The difficulty with ships' closets has been, in many cases, the heavy pull required to lift the closet-handle. To overcome this, a special valve is provided, fixed on the pedestal through which the water supply comes, and a pipe is taken from it to the closet inlet. The valve is actuated by a press knob, and does not require the user's hand to be kept on it. A regulating screw is attached, by which the amount of water passed can be governed. The action, therefore, is very simple. Similar closets are provided in the second-class lavatories. In the third-class accommodation wash-down closets are fixed, made in strong glazed ware, with a door-action valve. The principle of the valve is the same as described above, but it gives the flush when the door is opened to enter and a second flush when the door is re-opened for leaving. These closets are fixed in ranges, attached to a 5-in. pipe, and this pipe is flushed by automatic tanks at certain intervals. The closets for the crew are generally in the same style, but the flushing arrangement differs. The urinals are of special pattern, made with Doulton's white glazed circular backs, and discharging into a channel. On shore these channels are fitted below the ground level, but on the ship a step has been placed, so that the deck is in no way disturbed, and the channel is covered by a removable hinged grating.

Fig. 138.—A Needle Spray.

To prevent noise the lavatory floors of the first-class accommodation are covered with indiarubber tiling of varied design and colour, supplied by the India Rubber, Gutta Percha, and Telegraph Works Co., Ltd. Encaustic tiling, supplied by the Porcelain Tile Co., Hanley, has been laid in the second-class lavatories upon the lower deck, while encaustic mosaic tiling, supplied by Messrs. Doulton, is fitted upon the shelter and promenade decks.

Everything connected with the sanitary outfit has been designed with a view to simplicity, enabling the fittings, if necessary, to be taken to pieces and readily re-fixed while the vessel is at sea.

* * * *

National Telephone Service.*

For the convenience of passengers a complete telephone service connected with a central battery private branch exchange has been fitted by the National Telephone Company. The equipment is designed to be connected with the Liverpool and New York Exchanges when the ship is in port. We believe this is the first instance of a complete private branch exchange, giving regular exchange facilities, being fitted on an ocean-going steamer, and it would appear that a new field of considerable importance has been opened up for the telephone exchange service. The installation on the *Mauretania* consists of 89 stations and ten exchange lines connected to a switchboard having capacity for 200 stations and twenty exchange lines. The telephone instruments are fitted only in the regal and first-class staterooms, in the cabins of the ship's doctor, purser and chief steward, and in the bureau. The instruments are of special construction and of the design shown in Fig. 139.

*For this description we are indebted to the *National Telephone Journal*.

The switchhook is designed to grip the receiver and prevent the latter falling down or knocking against the side of the instrument when the ship rolls. That part of the switchhook which holds the receiver is also pivoted horizontally, so that the receiver may swing with the ship and always tend to maintain the active length of the lever. If this provision were not made the latter would lift with the rolling of the ship, owing to the shortening of the horizontal distance between the centre of gravity of the receiver and the fulcrum of the lever. The bell, induction coil and condenser are all fitted in a box having a metal cover enamelled white. In most cases the bell boxes are placed completely out of sight, and the wiring between them and the instruments is run behind the panelling of the cabins.

A room amidships has been set apart for the switchboard and exchange apparatus. The switchboard is of special design, having the power board placed on the top, as shown in Fig. 140. The distributing frame is of the vertical type, fitted with 120 pairs of fuses in the upper part, and 120 pairs of arresters and heat coils in the lower part. The whole is enclosed in a mahogany cabinet, and the space between the fuses and arresters is used as a cross-connecting field. Two ringing machines have been provided and are run from the ship's supply; these are enclosed in a sound-proof case and are controlled by switches on the

Fig. 139.—Telephone Instrument.

power board. Two batteries, each consisting of thirteen accumulator cells, are provided to supply current for the operation of the switchboard. These cells are conveniently situated in a special case close to the switchroom. They are charged direct from the ship's supply (110 volts) through a reducing resistance consisting of four 32-candle-power lamps. The charging and discharging of the batteries is controlled from the power board.

Calling is effected by means of lamps, but without relays. As the lines on the ship were uniformly of low resistance, it was found to be quite practicable to light the 24-volt calling lamp by means of the current from a 26-volt battery passing through the instrument when the receiver was removed.

The exchange junction lines terminate on self-restoring drops. In the case of an exhange junction line from a magneto exchange, a special circuit which will supply current for speaking must be provided.

Fig. 140.—Telephone Switchboard.

Ten pairs of wires for exchange junction lines are carried in lead-covered cable from the distributing frame to each side of the ship, where they are terminated in a box of special design.

On the landing stage or dock where the ship will be berthed are fitted a series of similar boxes, each having the ten junction lines from the town exchange terminating on them. These boxes are so placed that in whatever position the ship is berthed one of them will be within easy reach of the box on the ship.

A length of special flexible cable containing ten pairs of wires, and fitted at each end with a cable head, is provided for effecting connection between the ship's box and the shore box.

When the cable head is placed in position on the fixed terminal box and pressed home, a spring catch is automatically brought into operation and holds the cable head firmly so that studs upon the movable cable head make good contact with springs in the fixed terminal box, thus connecting the exchange junctions through to the ship switchboard.

At the Liverpool landing stage three shore boxes are provided. Each box is fitted in a special pit, sunk near the edge of the stage, the ten pairs of exchange lines being run to each of the pits underneath the flooring of the landing stage.

* * * *

Magneta Clocks.

THE *Mauretania* is fitted throughout with the Magneta Company's electric clock system, which has also been applied to a number of the more important vessels recently launched. The apparatus consists of a modification, suitable for ship conditions, of the well-known Magneta system, which is widely in use on land. The installation consists of forty-five Magneta secondary clocks distributed throughout the ship, all actuated by a centrally placed Magneta marine master-clock. All batteries are absolutely abolished and contact points eliminated, and no outside source of current is required. Perfect arrangements are also provided for setting the system of secondary clocks throughout the ship in accordance with time correction needed by her course. The most important advantage of the system, however, is that when once the Magneta secondary clocks are properly installed in the positions assigned to them they require no further attention and the fronts can be permanently closed down, so that the clocks cannot be interfered with.

* * * *

Heat and Sound Insulation.

To prevent heat travelling from the machinery spaces into the passenger accommodation, the decks immediately above the engine and boiler rooms, and all the light and air shafts leading into these spaces, have been lined with non-conducting material. This insulation has entailed a very large outlay both in material and labour, but as the work is all hidden its magnitude is not apparent upon a casual inspection of the finished ship. Various substances were used, the main object in view being to adopt that material which combined the minimum of weight with that non-conducting efficiency which the various positions required. The deck insulation below the lower and main decks consists of silicate cotton supplied by the Tees Slag Wool Company, of Middlesbrough, the material being held in position by a sheet steel covering. The vertical insulation round the engine and boiler casings from the lower to the shelter decks and the roof insulation over the galleys consist of mica in the form known as "Mica mattresses" supplied by the Mica Boiler Covering Co., of Widnes, and is also held in position by sheet steel. Above the shelter deck the engine and boiler casings have been covered with "Remanit" insulating mats supplied by Messrs. J. H. Bentham & Co., Newcastle, the mats being held in position by the wood panelling against the casing sides. This material is very light and is also an efficient sound deadener. The stokehold ventilators have therefore been insulated with "Remanit" for their full length to deaden the noises due to traffic upon the ladders inside and the hoisting of ashes, &c. For insulation round small trunks, round the ventilating ducts in the public rooms and in places where protection was required for the woodwork, a large quantity of "Uralite" has been used.

* * * *

Hardware.

THE hardware fittings are all of the highest class, many of them having been specially designed for the vessel in the Joinery Department at Wallsend Shipyard. Among the most noticeable fittings are the cabin hooks for holding open the cabin doors, which, owing to their patent spring action, are absolutely silent both in and out of use. Each swinging mirror is hung upon a set of patent movements, which will keep it steady even in the roughest sea.

The hinges which carry the upper beds are of an improved type, to facilitate folding up when not required and removal for general cleaning or other purposes. The type of hinge used for the fold-up lavatories is another patented invention, which, although simple in construction, is most ingenious in design and

enables one or more flaps to be hung from a common centre. In addition to the fold-up basin flap, each lavatory in the ship has a writing flap or shallow tray hinged in front, and by means of this patent hinge either the writing flap or basin can be opened at will.

Many new shapes and features are also to be found among the handles and mirror fittings, and special attention has been given to the handles on the dressing tables and similar furniture, which combine a pleasing appearance with a useful and serviceable design.

All the locks, and door, wardrobe and cupboard fittings, and the metal fittings for the deckhouse windows, have been supplied by Mr. James Gibbons, of Wolverhampton, and are mostly of polished white metal, so that corrosion will be avoided as much as possible. Altogether, some two thousand door and wardrobe locks have been fitted. All differ, but are divided into sets so that each steward has control of his own particular compartment, while a grand master-key gives access to all the compartments on board.

* * * *

Timber.

The quantity of high-class timber embodied in the woodwork of the vessel is enormous, and at least thirty distinct varieties of timber have been used, without including fancy woods for inlays. Advantage has been taken of the natural beauties of the various woods, and by judicious selection and conversion of the timber some most beautiful and pleasing effects have been produced. Yellow-pine is the largest item upon the list, having been used for all the deck sheathing, while in addition the main part of the bulkhead framing throughout the ship is constructed of $1\frac{1}{2}$-in. pine. The yellow-pine decks, purchased from Messrs. Robson, Miller and Co., Newcastle-on-Tyne, have been selected from the finest stocks, specially imported for the vessel. The yellow-pine for framing has been mostly supplied by Messrs. Joseph Owen and Sons, Liverpool. Venesta boards have been adopted for the panels in way of all the pine framing and have proved entirely satisfactory, a considerable saving in weight having been effected by their use. Next to pine in regard to the quantity used comes mahogany, the whole of the cabin bulkheads between the promenade and boat decks being of this wood, in addition to the panelling of the first-class lounge, the second-class smoking and other rooms, and the majority of the furniture. The mahogany is of a good quality, chiefly of African growth. Oak of the best Austrian growth, and selected for high figure, has been extensively used, the first and second-class dining saloons and the restaurant being executed in this wood, while the parquetry flooring in the saloons and smoking rooms is also of Austrian oak. The greater portion of the oak has been obtained from Messrs. Wm. Mallinson & Co., of London, whose supply was all of more than four years' seasoning. Altogether, Messrs. Mallinson provided just under a quarter of a million square feet of fancy hardwoods for the vessel, which must be a record for one ship. Some specially good highly-figured wide Austrian oak was obtained from Messrs. Jos. Thompson and Co., of Sunderland, who also supplied a large quantity of walnut; while a large quantity of various woods was purchased from Messrs. Wm. Oliver & Sons, Ltd., of London. Teak, which always plays an important part in ship-work, has been used in all portions exposed to the weather, including exposed doors, storm rails, seats, gratings, stairways and ladders, besides other parts where durability is essential. The second-class entrance is entirely done out in highly-figured teak, and it would be impossible to secure a better effect in this wood than is here obtained. Walnut of various kinds is also used extensively, many of the cabins being fitted throughout in this wood. The first-class smoking room, the staircase, the grand entrances, spandrels and bureau are formed of French walnut of the highest quality, over 10,000 square feet of veneer being required to cover the respective bulkheads. Specially prepared sycamore, in various shades, occupies a most prominent position, having been employed for the first-class library, the captain's bedroom and many of the special staterooms, with a most pleasing effect. A large amount of maple has been used, the second-class drawing room being entirely of this wood. Some of the special rooms are tastefully fitted out in pear-tree wood. Birch, beech and ash have also been used in considerable quantities for the third-class public rooms, the pantries and galleys.

The Electrical Installation.

Central Station.

ELECTRICITY is more extensively employed throughout the new Cunard liners than in any other vessels afloat, the electrical installation of the *Mauretania* having a size equal to some of the generating stations on land for supplying a city of 100,000 inhabitants. The work has been carried out by Messrs. W. C. Martin and Co., Glasgow, London and Newcastle, who have had large experience in ship work. The central station is situated upon a flat at the level of the orlop deck in the auxiliary machinery room, and is divided into two separate compartments by a centre longitudinal watertight bulkhead. The generating plant consists of four Parsons turbo-generators of 375 kilowatts each, two being placed in each compartment; so that in the event of one side being flooded, half of the plant will still be available.

Turbo-Generators.

THE turbo-generators have been supplied by Messrs. C. A. Parsons & Co. from their Heaton Works, Newcastle, and are each capable of supplying 4,000 amperes at 110 volts when run at a speed of 1,200 revolutions per minute. The arrangement of one generator is illustrated by Fig. 141, in which the casing is removed to show the turbine blading. The dynamos are shunt-wound and the armatures are of the surface drum-wound type with one turn per section. The connections between the conductors and commutator bars are made flexible as a safeguard in case of relative movement, but no such movement ought to occur. Insulation tests were made of the whole machine with an alternating pressure of 2,000 volts between the conductors and the frame, and gave not less than one-half of a

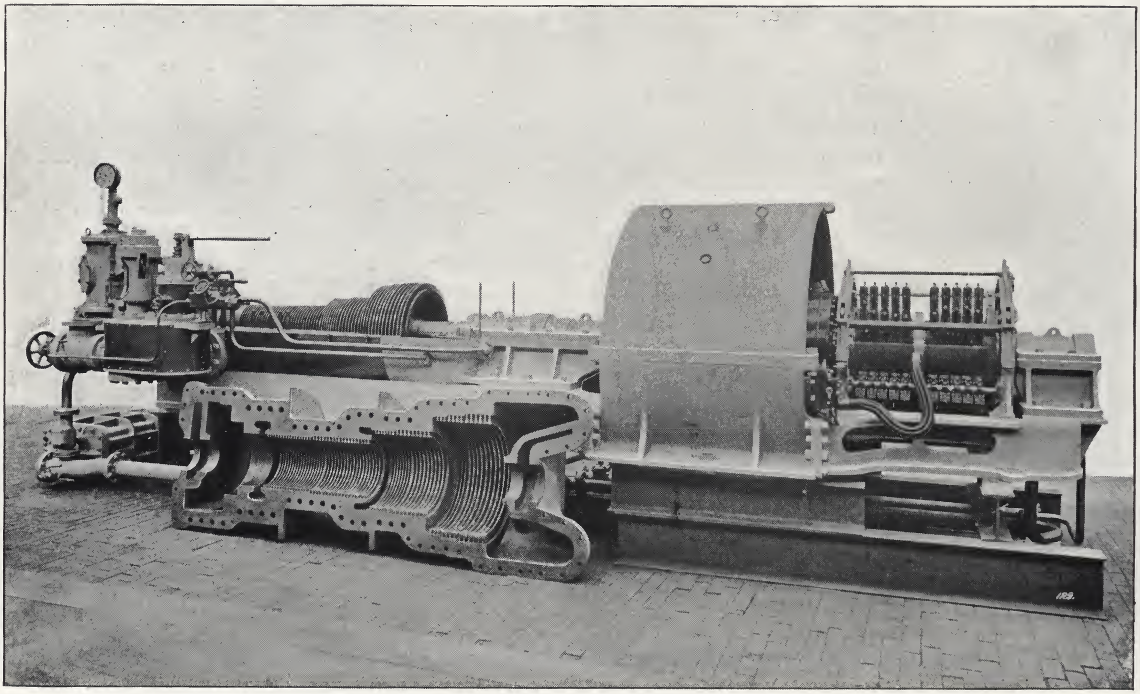


Fig. 141.—Turbo-generator.

megohm for the whole machine, one megohm for the armature winding, one megohm for the field winding, and one megohm for each of the brush holders. Special attention has been given to the connections of the bed plate to the deck, on account of the high rate of revolutions, indiarubber and wood packing pieces being introduced in order that these connections may not be too rigid and cause vibration. Tests were made at the Heaton Works with the generator running upon a specially constructed platform similar to that intended to be fitted in the ship, and demonstrated that no trouble need be feared in this respect.

* * * *

Main Switchboards.

THE main switchboards form a very fine piece of work and are illustrated in Fig. 142. One board is placed in each of the two station compartments, but the two boards are arranged for coupling together as one if required. Each is fitted with a main circuit breaker of 4,000 amperes, and 12 circuit breakers of 1,000 amperes. In addition to these, there is a time limit regulator, so that any sudden load thrown on by the starting of various motors will not open the circuit breakers under the time limit. Each generator panel is also fitted with an ampere gauge and voltmeter, and separate instruments are provided for taking the power of the various circuits and adjusting the voltage of the four generators. The base upon which the gear is mounted is of slate, $1\frac{1}{2}$ inches thick, erected on iron angles and forming an entirely fireproof construction. Twelve auxiliary switchboards are placed in convenient positions throughout the ship.

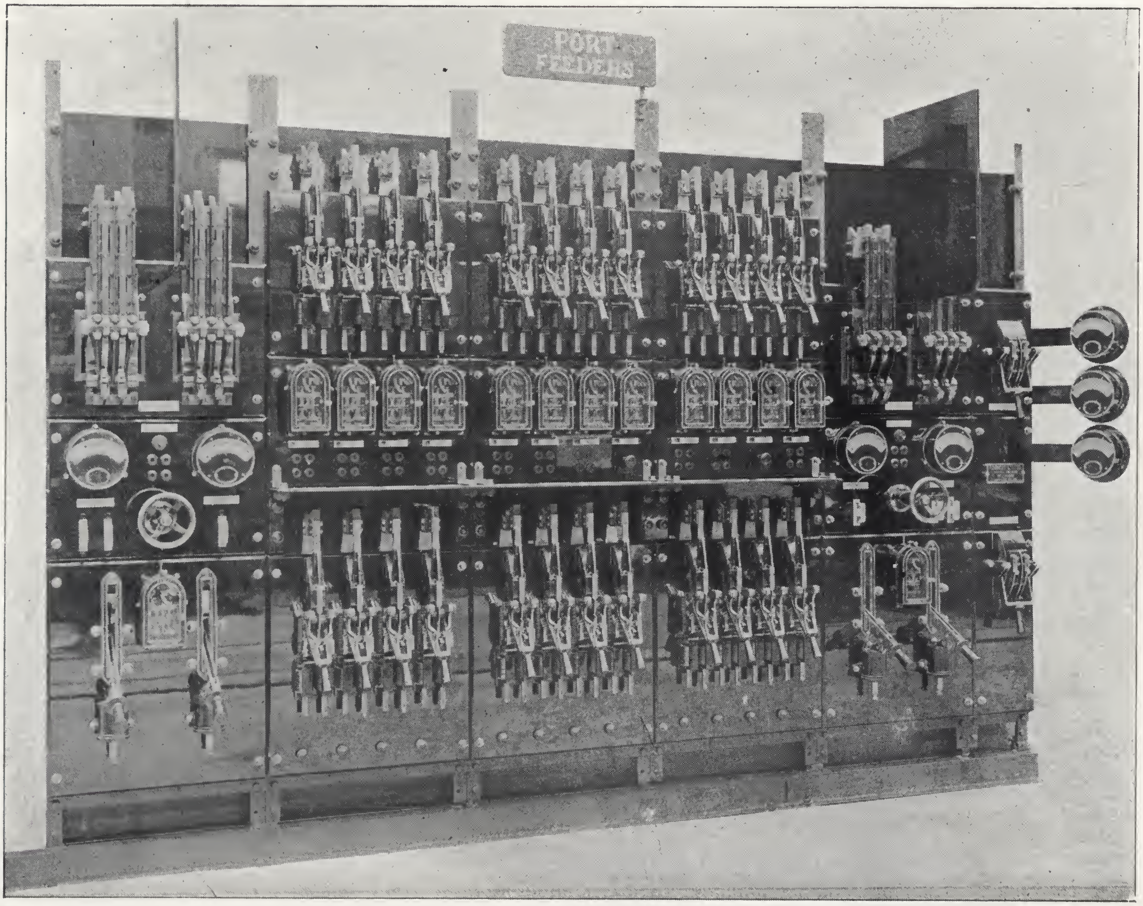


Fig. 142.—A Main Switchboard.

Cables.

For the transmission of the electric power, nearly 100 tons of copper cables were required. This quantity, if placed end to end, would extend for a distance of 250 miles, a figure which gives some idea of the tremendous amount of work involved in the installation, as does also our illustration (Fig. 143) showing some of the cables in the makers' yard. The Admiralty requirement that the cables should be placed below the water-line necessitated their passage through the boiler rooms, and to withstand the heat they had to be specially prepared with a heat-resisting compound, and covered with an outer sheathing consisting of two coats of asbestos braid. A section of the cable is shown in Fig. 144. The cables run along the bunker side on porcelain insulators, and are cased in with sheet iron for protection.

Fig. 143.—Some of the Cables in the Makers' Yard.

* * * *

Electric Lighting.

Altogether some 6,000 lamps, of 16 c.p., are distributed throughout the ship, of which 720 are fitted in the engine-rooms and stokeholds. The electric light fittings in the public rooms are of a very handsome design, specially prepared to harmonise with the character of the decorations, as may be seen in the illustrations of the various rooms. The fitting in the centre of the second-class saloon dome is shown in Fig. 145. In a large number of first-class staterooms portable reading lamps are fitted, in addition to handsome ceiling lamps, and the wiring is so arranged that the latter can be switched on or off either from the door or the bed. The plugs for the portable lights serve also for connecting the electric heaters, curling tongs and fans fitted in the berths. The fittings in the first and second-class staterooms are all in polished white metal, and have been largely manufactured by Messrs. William McGeoch & Co., Glasgow, who have also made some of the special fittings in the public rooms.

A 24-inch searchlight, of the Admiralty type, is provided, complete with four searchlight circuits at different positions in the ship. The navigation lights are fitted with Martin's patent

duplex indicator on the navigating bridge, as shown in Fig. 146. This apparatus registers any failure in these lights, and at the same time automatically switches on a spare filament in the lantern, thus avoiding its total extinction.

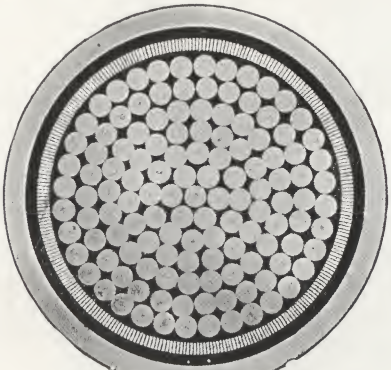


Fig. 144.—Section of Main Cable.

Electric Bells.

A COMPLETE service of electric bells has been fitted throughout the first and second-class accommodation by Messrs. Martin, each set of cabins having an indicator placed in a convenient position in the alleyways. The total number of bell pushes is about 950, and indicators 40. At night, when the berth stewards are off duty, a connection is switched on from each indicator to a master indicator placed where the night steward is stationed, so that when any bell is rung indication is given both at the section and master indicators.

* * * *

Electric Heaters.

ABOUT 40 electric convectors of $2\frac{1}{2}$ amperes each, have been fitted in the first-class bathrooms; and radiators of 7 amperes' capacity have been fitted in about 50 of the special staterooms, wall plugs being arranged to suit.

* * * *

Transmission of Power.

IN no other vessel has electricity been so extensively introduced for ventilating, heating, and driving auxiliary machinery. There are about 150 different motors altogether, varying from the 50 horse-power motors for the forced draught fans to the tiny $\frac{1}{4}$-horse-power motors for boot and knife-cleaning machines, potato peelers, etc. Altogether there are 24 main feeder circuits, including 8 fan-room circuits, 2 engine-room power circuits, and 14 electric lighting and power circuits throughout the ship. Four large motors operate the opening and closing of the main exhaust sluice valves, other four are provided for turning the main shafts, and six operate the turbine cover lifting gear. Two motors are connected to the bilge pumps, and three are fitted to the refrigerating machinery forward. The passenger elevators, and hoists for the mails, baggage and galley stores, are all electrically driven, as are also the 4 jib baggage cranes aft and 4 boat winches. For heating and ventilating no less than 90 motors have been fitted, for driving the engine-room and fan-room ventilating fans the thermo tanks supplying hot or cold air to the passengers and crew, and the exhaust fans from the galleys and lavatories; while in the galleys a large number of motors are provided in connection with the cooking apparatus.

* * * *

Wiring.

AN immense quantity of wiring has been required. In addition to the wiring for the electric lighting, bells and power circuits, Messrs. Martin have also fitted the wiring for the fire alarms, the Magneta clocks, and the three telephone systems, of which a description will be found elsewhere.

Fig. 145.—Electrolier in Dome of Second-class Dining Saloon.

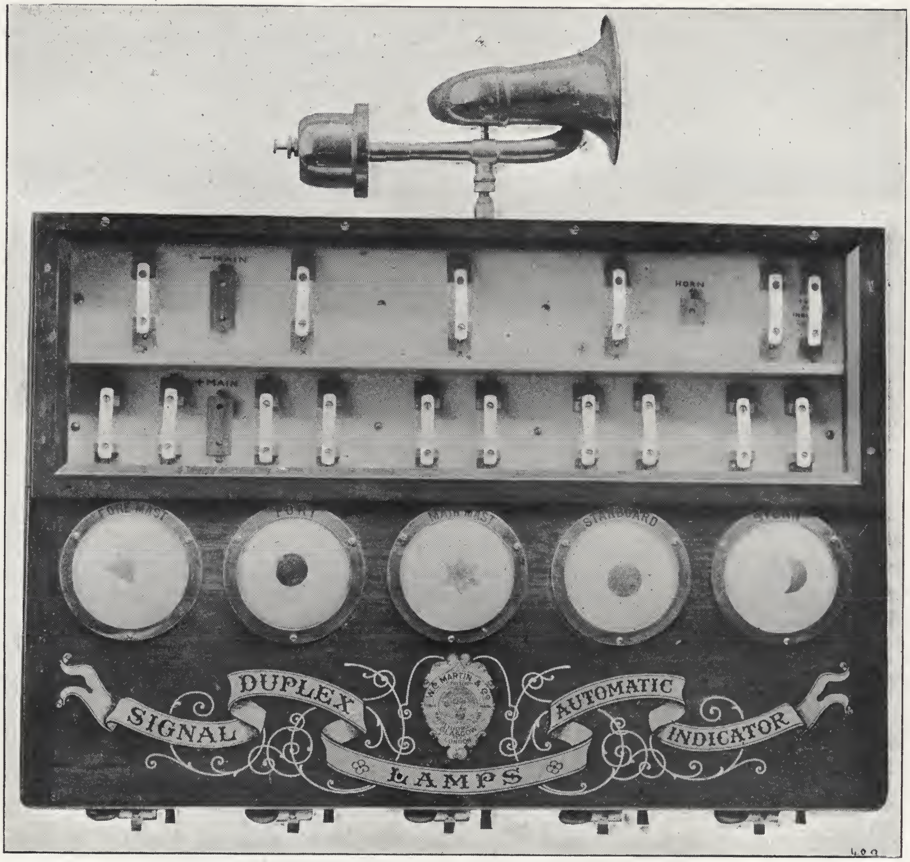


Fig. 146.—Duplex Indicator on Navigating Bridge.

Arrangements for Working Cargo, &c.

The Refrigerating Installation.

COMPLETE and independent installations of refrigerating machinery, for the preservation of the ship's provisions and for the carriage of perishable cargo, have been fitted on board by the Liverpool Refrigeration Co., Limited.

The ship's provision machine is situated near the forward end of the main engine room on the main deck, and the chambers on the lower deck over No. 4 boiler room and bunker. The latter have been insulated by the Shipbuilders with granulated cork in combination with specially treated damp and rot-proof paper, with linings of white pine boards. The chambers are divided into compartments for mutton, poultry and game, bacon, milk, fruits and vegetables, and ice. The wine, beer and spirit chambers are also lightly insulated and cooled to a suitable temperature. The total capacity of the chambers inside insulation is about 13,000 cubic feet. In addition, a large cold larder is fitted on the upper deck, and cold boxes are placed in the first and second-class bars and still-room.

An installation is also fitted for the supply of cooled water for drinking and other purposes. In fact, every possible requirement has been considered and arrangements made, not only for the preservation of the perishable provisions in bulk, but also for the convenience of the catering and culinary departments generally, the installation forming, we believe, the largest and most complete of its kind in existence.

The machinery is of the carbonic anhydride type, and consists of a horizontal, compound, duplex machine (see Fig. 147), mounted on a cast iron boxbed, which is divided by a longitudinal bulkhead into two portions, each of which contains an independent set of gas condenser coils.

The compound steam cylinders drive, from their tail rods, two horizontal, double-acting CO_2 compressors. A neat arrangement of steam valves is fitted, so that the engine can work compound or independently as two high-pressure engines, and all the connections are arranged in such a manner that the machine is the full equivalent of two independent machines combined on one base.

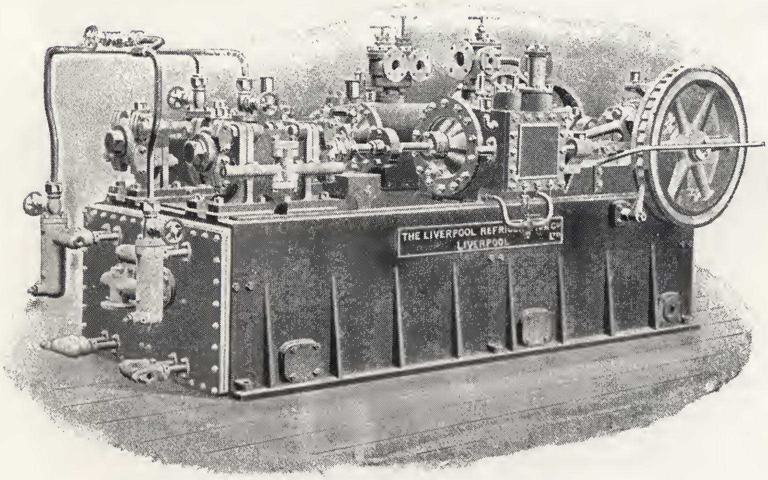


Fig. 147.—Steam-driven Refrigerating Engine aft.

The evaporator is of the vertical type, the shell enclosing two independent nests of circular coils, one coupled to each compressor, with cross connections similar to those for the condensers.

Two horizontal, duplex, brass-fitted brine pumps circulate the brine, and a third smaller

and independent pump is provided for the special duty of pumping the brine supply to the cold larder and refrigerators in the saloon bars and other places. The brine is drawn from the evaporator and delivered into a distributing header, with valves and connections leading to the various pipe sections in the cold rooms. After passing through these, the brine returns to a similar collecting header, and thence back to the refrigerator. No open brine tanks are fitted, the system being entirely closed. All the chambers are cooled with galvanized brine piping, arranged to suit the various temperatures required in the several compartments, each compartment being regulated independently of any other.

The insulated cargo chambers, six in number and of about 20,000 c. ft. inside capacity, have been fitted in the orlop 'tween decks forward, for the carriage of frozen meats, particularly chilled beef, and poultry, cheese, bacon, butter and fruits. The compartments, which are quite independent of each other, can be supplied with brine for cooling at a higher or lower temperature, as necessary to suit the cargo carried, and have been insulated by the Shipbuilders with granulated cork in a similar manner to the provision rooms. All the chambers are cooled with galvanized wrought iron piping, and fitted with meat rails and removable hooks for hanging chilled meat, and also removable side tables for the storage of fore-quarters.

The cargo machinery, situated on the starboard side of shelter deck forward (see Fig. 148), is also of the carbonic anhydride type. The plant is in duplicate throughout, and is electrically driven. As the machinery is at a considerable distance from the chambers, a brine-distribution house has been fitted on the shelter deck near to the chambers, from which the regulation and distribution of the cold brine is controlled.

The two horizontal gas compressors, each directly coupled to a powerful electro motor, as shown in Fig. 148, have been specially arranged for long continuous running. The motors, designed and constructed for the purpose by Messrs. Boothroyd, Hyslop & Co., of Bootle, are so arranged that, by means of shunt regulation, they can run at any desired speed, from 40 to 110 revolutions per minute. The speed is regulated by the turning of one hand-wheel only, the motor running at the same speed as the compressor.

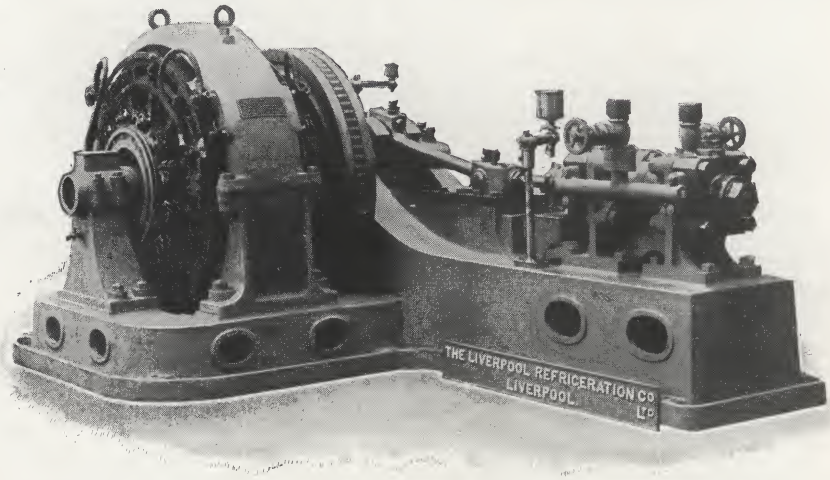


Fig. 148.—Electrically-driven Refrigerating Engine forward.

The gas condensers, of the vertical type, are independent, and consist of soft lap-welded coils of wrought iron, galvanized on the outside, and contained in galvanized wrought steel shells. The evaporators are similarly constructed to the condensers, ample facilities being provided for easy access to the coils for cleaning.

Two high-lift "Gwynne" centrifugal pumps circulate the brine. These are directly coupled to variable speed electro motors, supplied by the same makers as the main motors, and so arranged that the speed of each pump can be regulated to suit the resistance to be overcome, this resistance varying somewhat according to the number of chambers in use.

When carrying chilled and not frozen cargo, the temperature must be regulated with great accuracy, as the variation of a single degree Fahr., up or down, may be fatal to landing the cargo in prime condition. A brine supply at an accurate and easily regulated temperature is, therefore, of great importance, and special means, including a Webb's patent attemperator, have been provided for attaining this object. Warmer brine is circulated by an independent pump, and in the distribution room special duplex headers have been arranged, so that either cold or warmer brine can be supplied to the cooling pipes in any one or more chambers. The attemperator consists of a simple three-ported slide valve, enclosed in a cast iron casing, and attached to a screwed spindle with a hand wheel, so that the movement of the valve over the ports can be accurately regulated as required. A branch from the cold brine supply main is coupled to one end of the valve casing, and the return warmer brine main is coupled to the other end, the mixed or attemperated brine escaping through the central port and pipe connected to the warmer brine pump. In working the apparatus, the warmer brine pump draws from the mixing or attemperating valve chamber, delivering to the headers. Thence the brine passes through the pipes in the chilled chambers back to the attemperator, there to be mixed with any given proportion of the coldest brine necessary to lower its temperature to the required degree. The temperature can be regulated by means of the handle controlling the valve exactly as required, higher or lower, and the control is positive.

The brine circulation generally, as in the provision plant, is an entirely closed circuit. There are no brine tanks, except a small one for mixing brine in the first instance, for charging the machine, or for adding a little from time to time. Any little air or foul gas in the system is automatically disposed of through a small ventilating pipe carried outside from each evaporator. Though there are a large number of independent circuits, no trouble whatever is experienced in regulating each exactly as required. With the closed circuit there is no difficulty with air locks or aeration of the brine, and the system is surprisingly simple, clean, and easy to work.

* * * *

Baggage Cranes, &c.

Spaces for baggage have been provided in the lower holds both forward and aft, but the after spaces will generally be utilised for this purpose. The baggage will be lifted on or off the deck by means of four baggage cranes, situated abreast the after mast, as may be seen from Plate V. The cranes, which have been supplied by Messrs. Stothert & Pitt, of Bath, are electrically driven and will each lift a load of 12 cwts. at a speed of 200 feet per minute. The same makers have supplied two electric winches, situated on the main deck forward, for dealing with baggage stowed in the forward room, these winches also being intended for a load of 12 cwts.

The after baggage is transferred from the shelter deck to the room below by means of two baggage lifts, one on each side of the ship. Entrance doors are also provided in the ship's side between the main and upper decks abreast of the lifts, so that baggage can be handled at this level if necessary. The baggage lifts have been supplied by Messrs. Waygood, and are each capable of lifting 2 tons at a speed of 100 feet per minute, their vertical travel being 34 feet. Messrs. Waygood have also supplied a number of smaller lifts, all electrically driven, including two 10-cwt. lifts for conveying stores from the shelter deck to the galleys and cold stores below, and five 2-cwt. lifts from the galley to the first-class pantry at the end of the upper dining saloon, from the third-class galley to the pantry below, from the stores to the deck pantry, from the coal bunkers to the first-class galley, and from the coal bunkers to the third-class galley respectively.

The mails will be placed in the mail room upon the lower deck aft, as shown on Plate VI. Adjacent to the large room is a smaller sorting room, provided with racks, so that sorting may be done on board. From the mail room, two trunked hatchways extend to the shelter deck and afford access for the mails into the compartment. Two electric hoisting winches, supplied by Messrs. Stothert & Pitt and capable of lifting 12 cwts., are placed one at each side for raising and lowering the packages.

The quantity of cargo carried being small, no elaborate arrangement of winches and derricks has been introduced. Two 8-in. by 14-in. steam winches, one at each forward hatch, supplied by Messrs. J. H. Wilson & Co., of Liverpool, were considered sufficient for dealing with the work forward; while any stores, etc., to be carried in the after peak can be lowered with the aid of the large warping winch aft, which is provided with a barrel for this purpose.

Navigating Appliances.

Steam Steering Gear.

In order to comply with Admiralty requirements the gear is situated entirely below the load water line and consists of two independent steering engines, the main and the auxiliary, placed in separate watertight compartments. As a further protection in case of the vessel being employed for war purposes, arrangements have been made for fitting a protective deck over the main gear, as shown by dotted lines in Fig. 149. The arrangement of the gear, which has been supplied by the well-known steering gear makers, Messrs. Brown Bros. & Co., of Edinburgh, is shown in Figs. 149 and 150. Owing to the fineness of the ship, the tiller is placed some distance from the rudder head, and the latter is worked by means of two long forged steel rods connected to the cross-head end of the tiller and to a Siemens-Martin cast steel crosshead mounted upon the rudder head. The tiller is also of Siemens-Martin cast steel and is supported at its after end by a dummy post cast in one with a large Siemens-Martin cast steel bracket which is firmly bolted to the deck. The main engine, which has cylinders 14 inches diameter by 14 inches stroke, is securely mounted upon the forward end of the tiller and drives—by means of worm gear, friction clutch and spur gearing—the main pinion, the latter in turn engaging a cast steel pinion rack firmly built into the ship. The rack is in three pieces so that the central part may be replaced in the event of the teeth becoming worn.

The auxiliary engine is placed upon the lower orlop deck in a separate watertight compartment forward of the main gear compartment. The engine is a duplicate of the main engine so far as its working parts are concerned, and drives by means of gearing a horizontal steel shaft which is carried through the watertight bulkhead. On the after side of the bulkhead this shaft drives a sprocket wheel, which engages a very strong forged steel flat link chain. The chain is held up to its work by two cast iron guide pulleys, from whence it travels to port and starboard and passes round a cast iron pulley at each side of the ship. The ends are returned towards the centre of the ship and are attached to a bridle which slides in a slot on a prolongation in the top jaw of the forward end of the main tiller. The bridle is connected by a forged steel pin to a square cast iron guide block below, which is held in position and, when the chain is moved by the engine, is made to travel in a straight line from port to starboard by means of a guide race built into the ship.

The rudder angle, when the telemotor stops are adjusted, is 35 degrees on each side of the centre line, but the gear is so arranged that an angle of 37 inches may be obtained before coming upon the rudder stops. Either engine is capable of exerting a twisting moment of 1,240 feet-tons upon the rudder head, the steam pressure in the cylinders being 150 lbs. and the back pressure 20 lbs.

The gear is controlled from the navigating bridge by either of two telemotors which can be connected independently to a wheel in the wheel house, while a third telemotor is connected to the wheel house under the after docking bridge. Three telemotor cylinders are provided in each steering compartment and are so arranged that they can be put in or out of gear from either side of the bulkhead. A charging pump and tank have been supplied for each compartment.

* * * *

Mooring and Warping Arrangements.

The anchors and cables for mooring the vessel are necessarily of massive proportions on account of her great weight and the large area of superstructure exposed to the wind. The anchors are of Halls' patent improved type and have been supplied by Messrs. N. Hingley & Sons, Ltd., of Netherton. The weight of the bower anchors is about 10 tons each, and some idea of their size may be gained by Fig. 151.

In order to snugly house the anchors the hawse pipes have been made of a novel design, which is illustrated in Fig. 152. A strong anchor

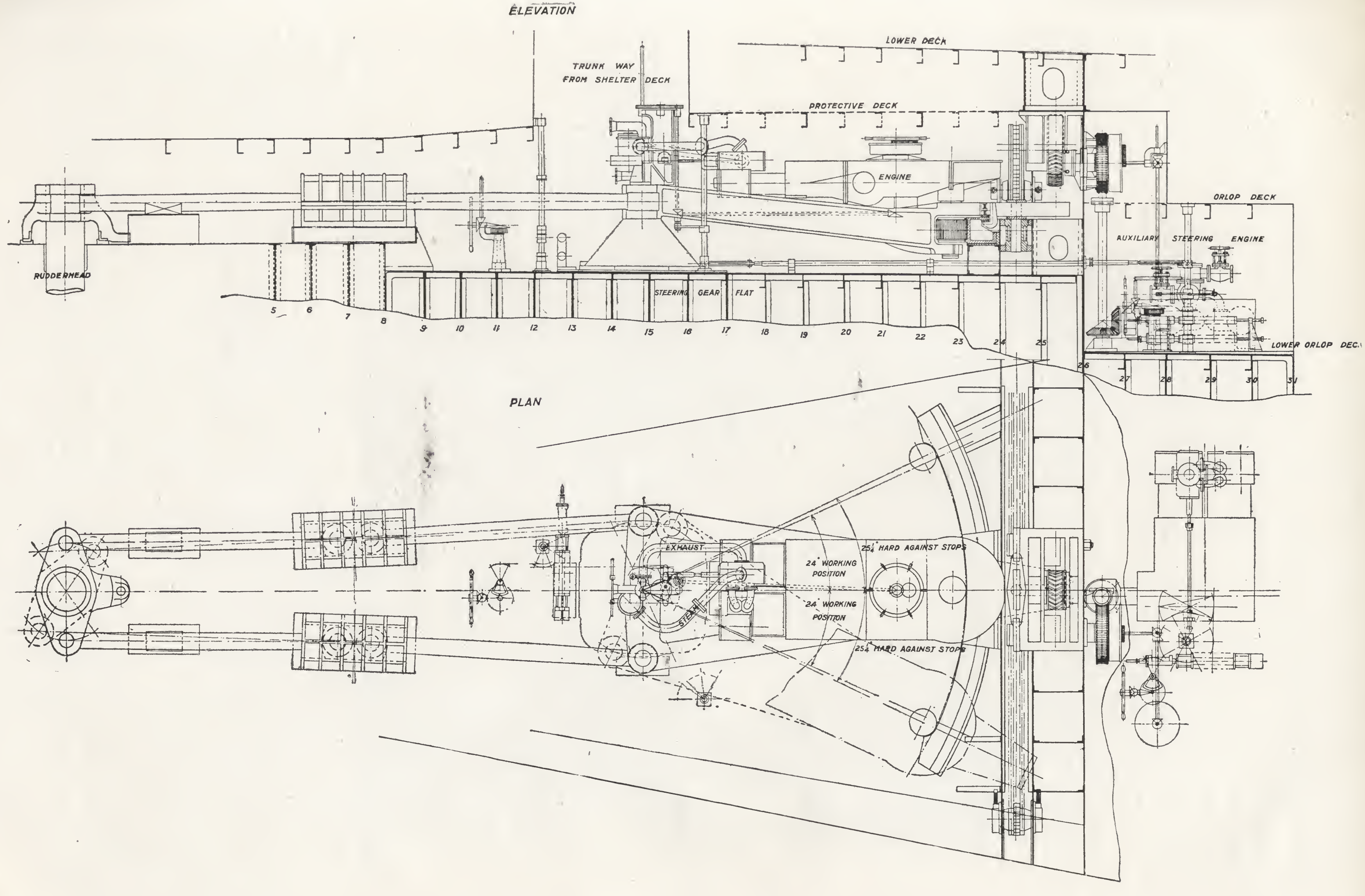


Fig. 149.—Steam Steering Gear.

crane is also provided for lifting the anchors on deck.

The cables have been made by Messrs. Brown, Lenox & Co., of Pontypridd. The links have a minimum diameter of $3\frac{3}{4}$ inches and are each $22\frac{1}{2}$ inches long and $13\frac{1}{2}$ inches wide, with a weight of 170 lbs. each. The cables are 1,900 feet long and weigh altogether about 130 tons. The anchor shackles, of which there are four, weigh 814 lbs. each. The cables are in twenty-two lengths, each length being joined on by a smaller or connecting shackle. At the outer end of each cable a large swivel piece is inserted so that the anchor may turn round without twisting the chain. The end links upon these swivel pieces are made of $4\frac{3}{4}$-inch diameter iron and the swivel alone weighs $6\frac{1}{4}$ cwts. In addition to the cable carried on the *Mauretania*, Messrs. Brown, Lenox & Co. have supplied a set of mooring chains, which are attached to the buoys specially laid down in the Mersey for mooring the ship. These chains are of record size, being $4\frac{1}{4}$ and $5\frac{3}{8}$ inches diameter, and are illustrated in Fig. 154. The swivel connection shown weighs no less than 2 tons, and each shackle 711 lbs.

The windlass drums or cable holders for winding the cables are placed upon the promenade deck as shown in Fig. 153. Each drum is mounted upon a vertical spindle which is carried down to the shelter deck. Upon the lower end of this spindle is keyed a bevel wheel of large diameter, the wheel being driven by means of worm gearing from a vertical engine having cylinders 20 inches diameter with a stroke of 14 inches, and capable of heaving in the cables at a speed of 50 feet per minute. Between the cable holders and the hawse pipes the cables pass over cast steel bow stoppers of the Admiralty pattern, suitable for holding the cables when the vessel lies at anchor. Ample arrangements have been made for warping the vessel in harbour. The forward gear for this purpose consists of four capstan drums placed on the promenade deck as shown in Fig. 153, all mounted on vertical spindles carried down to the shelter deck. The two foremost capstan spindles are driven by worm and bevel gearing in a similar manner to that adopted in the case of the windlass drums. The same engines are arranged to perform either of these duties, a system of clutches enabling the windlass drum to be thrown out of gear while the engine is working the capstan drums, and *vice versa*. The second pair of capstans forward are driven independently, each by a vertical engine having cylinders 15 inches diameter with a stroke of 12 inches. A similar arrangement of four warping capstans has been installed at the after end of the ship, the drums being placed

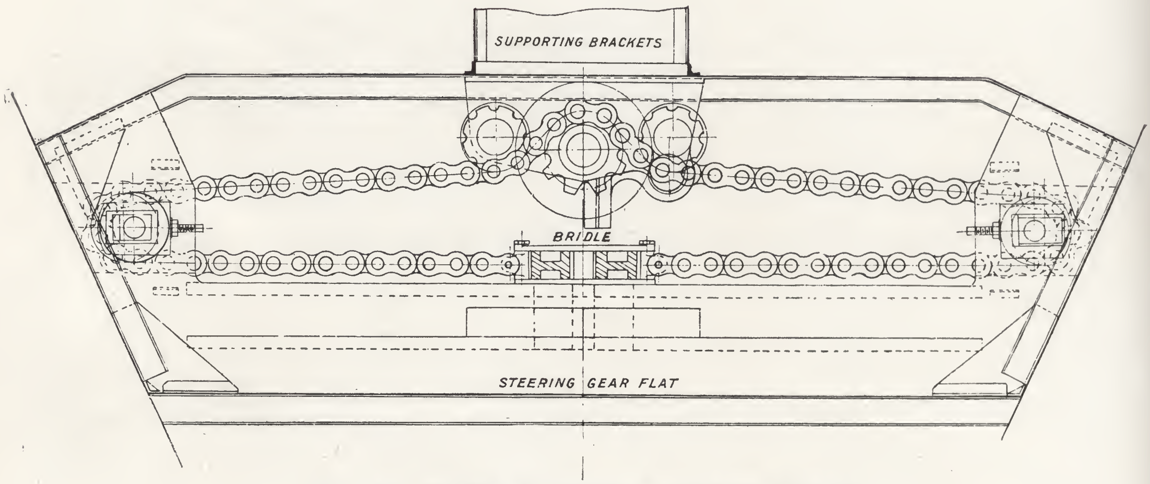


Fig. 150.—Section at Frame 24, looking forward.

upon the shelter deck in the positions shown in Plate VI., with the driving engines below in the spaces indicated. The capstans are each intended to warp at a speed of 200 feet per minute against a pull of 30 tons. The whole of the windlass and capstan gear has been supplied by Messrs. Napier Bros. Ltd., of Glasgow.

tended 28 feet from centre to centre of drums, and are supported by massive iron brackets standing upon the deck. The brackets are arranged so that they can be readily removed should guns be mounted on board.

A large number of mooring bollards or timberheads have been provided for securing the wire hawsers and warps. Owing to their

Fig. 151.—A Bower Anchor.

In addition to the capstans, a large warping winch has been fitted at the after end of the shelter deck in the position shown in Plate VI. This winch has been supplied by Messrs. J. H. Wilson & Co., of Liverpool, and is easily seen in Fig. 51, which illustrates the after end of the vessel. It is fitted with two 12-inch by 16-inch cylinder engines arranged with link motion reversing gear. The warping ends are 2 feet 3 inches diameter by 2 feet 4 inches long, ex-

large size it was considered undesirable to make the bollards in the usual form of a single iron casting, and they were therefore built of steel tubes with cast steel tops as shown in Fig. 156, the deck below being suitably stiffened.

* * * *

Boats and Boat-hoists.

The boats, sixteen in number, are placed on the boat deck in the positions shown in Plate V. The method of housing may be seen from

the illustration in Fig. 157, only half chocks being fitted on the deck and the davits being placed at the ends of the boats, so that the latter may readily be put over the side. The boats can also be carried entirely outboard, being then hung from the davits without resting on the deck, in which case large round padded fenders are inserted between the davits to prevent the boat swaying inboard, as may be seen from Fig. 155. For lightness the davits have been made of lapwelded steel tubes, 10½in. diameter by ⅝-in. thick, supplied by Messrs. Stewarts & Lloyds, of Glasgow and Birmingham. The boats, which are entirely of wood, have been made by Mr. D. Buchanan, of Walker, and are 30ft. long by 9ft. wide by 3ft. 9in. deep. Hill's patent disengaging gear has been provided for each. For raising and lowering the boats, four specially designed electric boat winches, supplied by Messrs. Laurence, Scott & Co., Norwich, have been fitted upon the sun deck in the positions indicated in Plate V. Each winch is capable of lifting 5 tons at a speed of 40 feet per minute, and this load may be distributed over the four warping drums which are provided, as may be seen in the illustration Fig. 158, which shows one of the winches fitted in position on the ship.

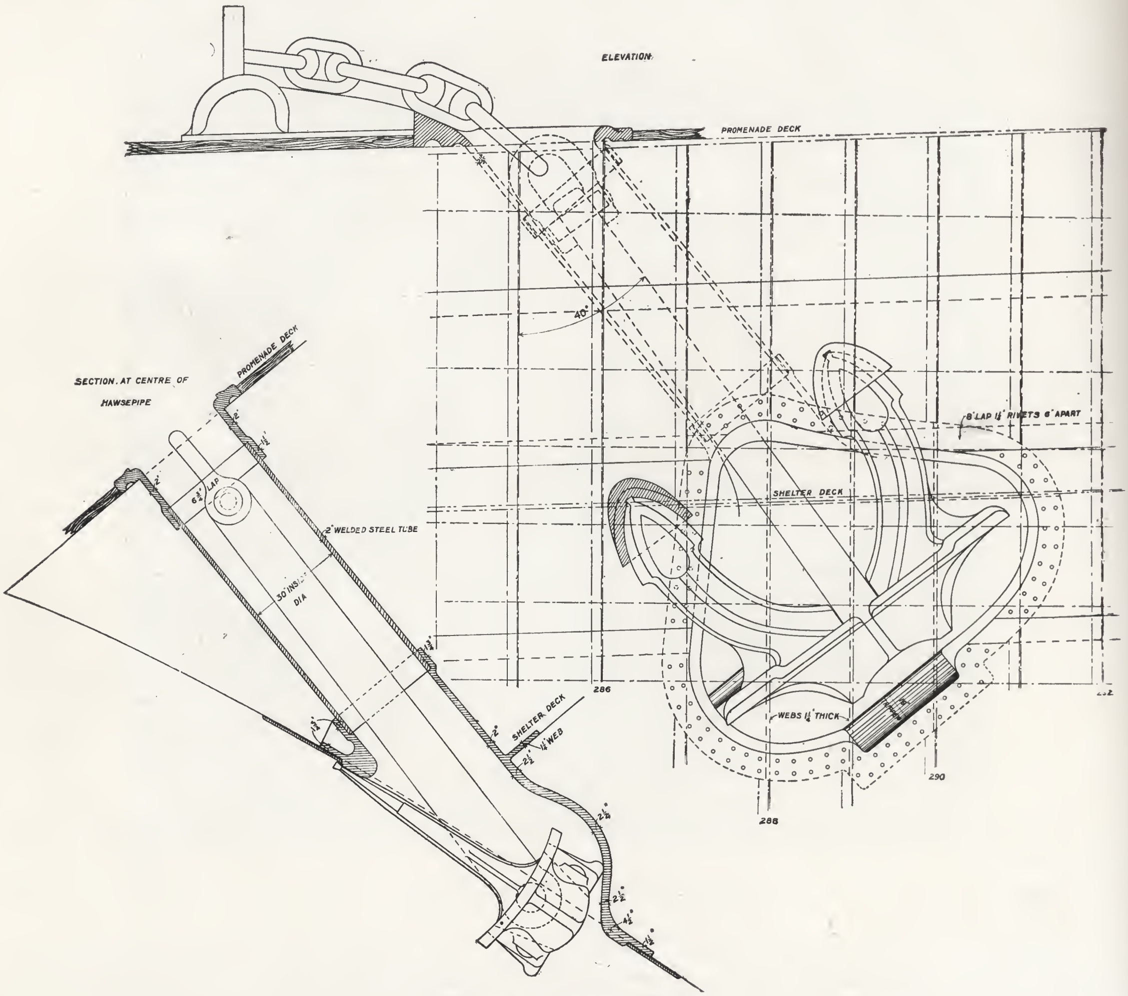


Fig. 152.—Hawse Pipes.

Fire Prevention.

THERE are two complete systems of fire mains on the vessel, one on each side of the continuous boiler casing between the lower and main decks. From each main, numerous vertical branches are led having hose connections at each deck. The service is also

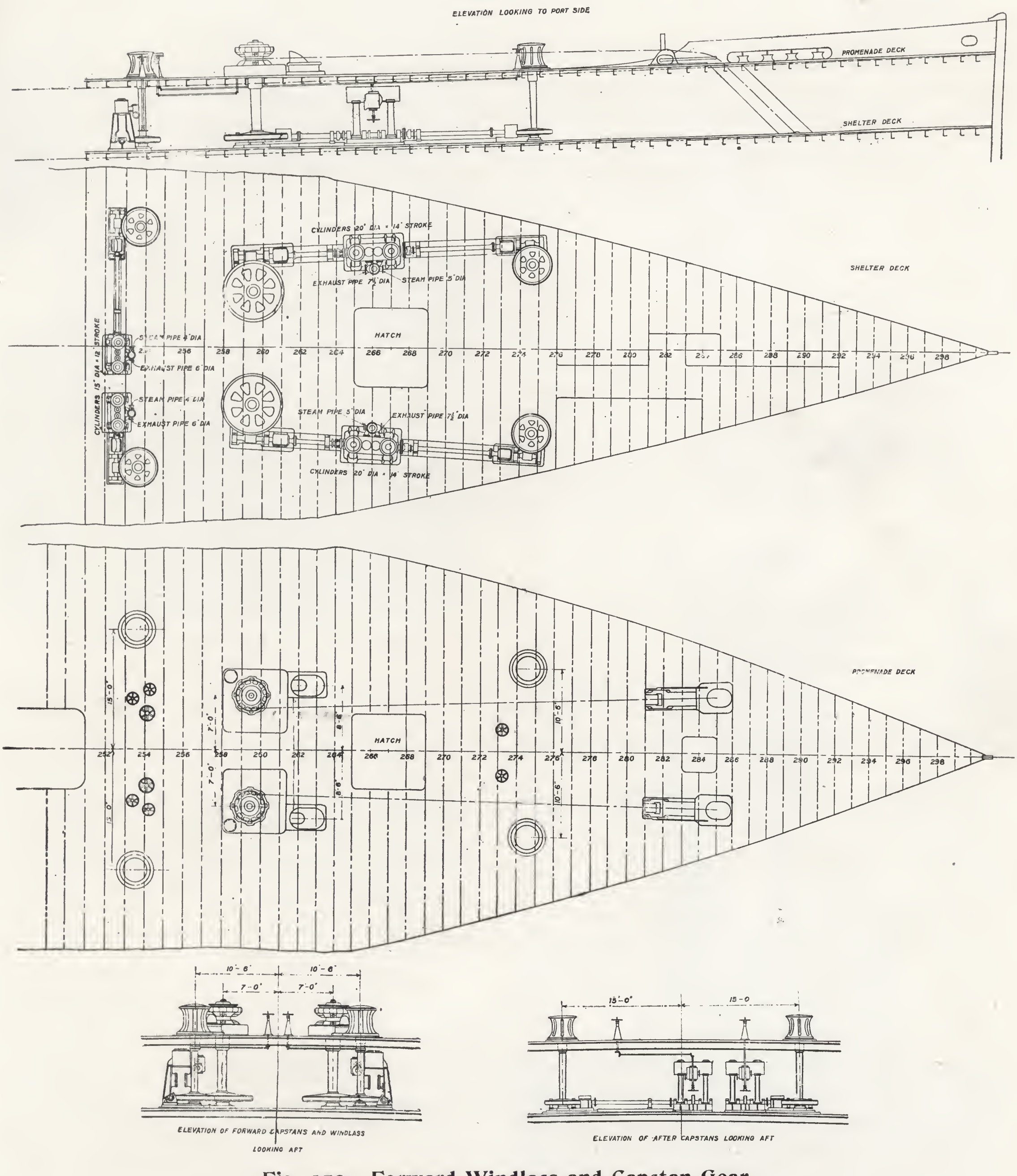


Fig. 153.—Forward Windlass and Capstan Gear.

intended for wash-deck purposes, and is maintained by special pumps in the engine room. In the first-class accommodation the hose connections are contained in small box compartments built into the casing sides, each compartment containing, in addition to the connection valve, a long length of leather hose wound upon a roller with a directing nozzle at the end. The interior of the box and its contents are painted red for ready identification. In the second-class accommodation the boxes with hose connections, etc., are usually fastened against the bulkheads in the lavatories and are also painted red. In the third-class the valves are exposed, no boxes being fitted, and they are painted red as a distinction from the remainder of the piping.

Numerous break-glass fire alarms are distributed throughout the vessel and these are also painted red. If the glass is broken a button may be pressed, and by electrical connection alarm is given at two indicators, one placed in the officers' house close to the navigating bridge and the other placed in the engine room.

Fig. 154. Mooring Chains.

Fig. 155.—Boat carried outboard.

As an additional precaution portable chemical fire extinguishers are placed at various points throughout the vessel.

To detect fire in the mail and baggage rooms Pearson's automatic alarms are fitted in these spaces. The action of Pearson's alarm depends upon the principle of expansion by heat. If a dangerous temperature is reached in the compartment a special part of the apparatus expands sufficiently to complete an electric circuit and give alarm at the indicators mentioned above.

The cargo holds are provided with Rich's fire-indicating system, illustrated by Fig. 159. An indicating station is placed upon the bridge on the port side of the officers' house, and to this station a pipe is led from each hold. Above the pipe outlets, is placed a small fan, driven by an electric motor, and controlled by clock-work so that the fan exhausts from the pipes every quarter of an hour. Should any smoke be present in a hold, it will be drawn through the respective pipe and observed at the station. A steam connection is provided, which can be

coupled on to any of the pipes, so that steam can be blown at once into the hold and the outbreak quelled at the outset.

* * * *

Submarine Signalling.

THE vessel is fitted with receiving apparatus for submarine signals on the system introduced by the Submarine Signal Co., whose signal bells have now been, and are being, installed at a large number of lightships, lighthouses and points of danger. The system is illustrated in Fig. 162, and consists of a submarine bell weighing about 150 lbs. and cast with a thick lip. This bell emits a high clear note when struck, the striking mechanism being actuated either by the waves or by electricity supplied from the shore. The sound is transmitted through the water to two small receiving tanks, about 22 inches square, attached to the shell plating of the vessel, one of which is placed on each side near the bow. A microphone is suspended, wholly immersed, in each tank, and wires connect this microphone with an indicator box in the wheelhouse. This box is of metal, circular in shape, and is fitted with two telephone receivers enabling two observers to listen simultaneously. By moving a switch the listener can locate the bell as being either on his port or starboard hand. The benefit of using water as the transmitting medium is that sound travels through water at five times the velocity it attains in air and with greater freedom from disturbing causes. The submarine system, therefore, provides better facilities for finding location in fog, and enables navigation to be carried on with almost as much assurance as in clear weather.

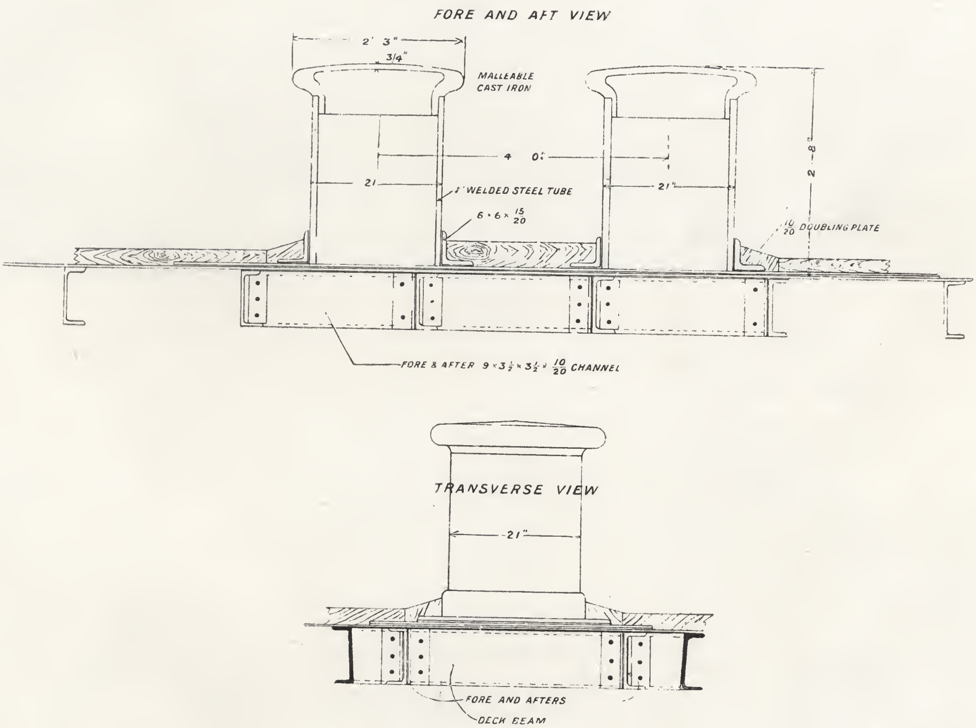


Fig. 156.—Mooring Bollard.

Fig. 157.—Housing of Boats.

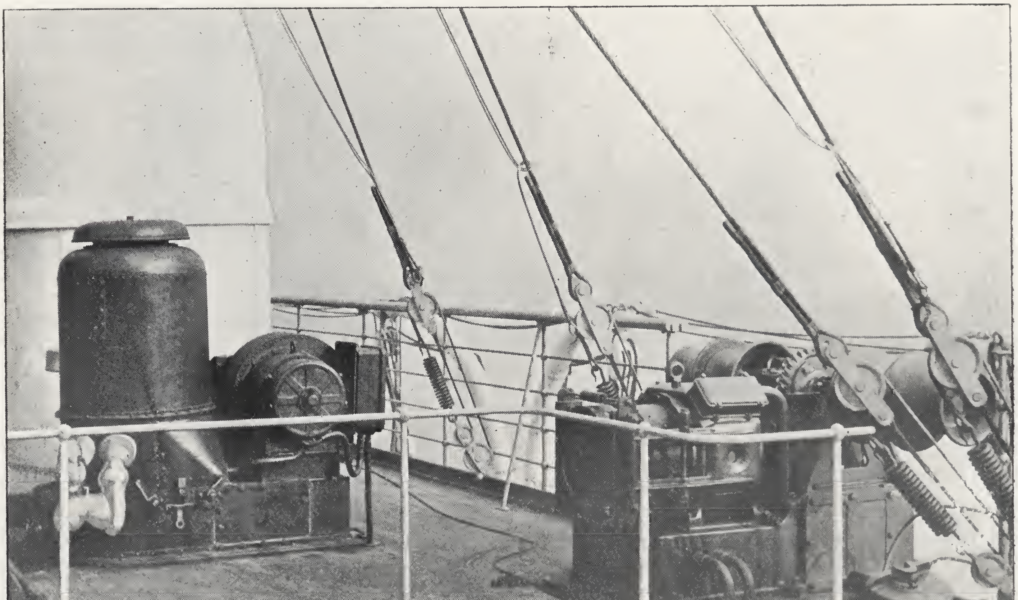


Fig. 158.—Boat Winch and Thermotank on Sun Deck.

Wireless Telegraphy. As in the case of all the large Cunard vessels, a complete installation of wireless telegraphy has been fitted on board, which will keep the steamer in touch with the outside world for practically the whole of her journey across the Atlantic. Communication can also take place with other vessels fitted with the system which may come within the range of influence of the instruments. The daily newspaper, which will be published on board, will contain all the latest wireless messages and keep the passengers well informed with regard to passing events all over the world. The house for the Marconi instruments is situated on the sun deck amidships, as shown in Plate V. There are two complete sets of apparatus, one for transmitting and one for receiving messages, the latter being placed in a soundproof chamber built in one corner of the house. The two parallel aerial wires required for the system extend between the fore and main masts, as indicated in Plate V. They are kept as high as possible, and are fastened at the ends to light booms, the latter being attached to the masts. From the aerial wires connecting wires are led to the instruments in the house.

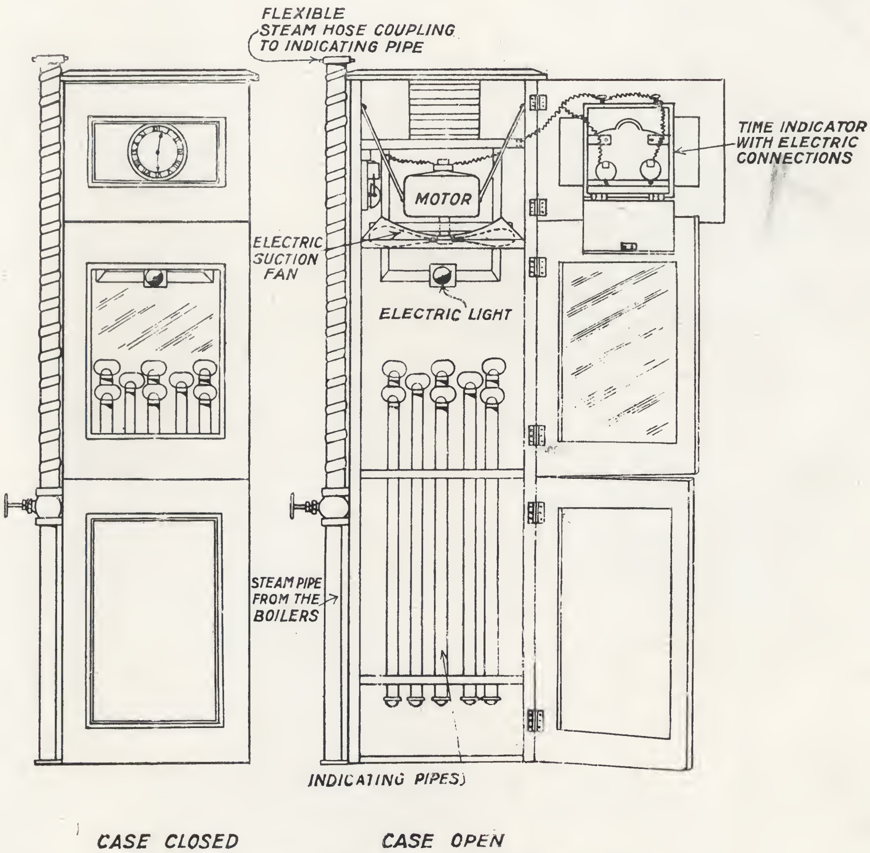


Fig. 159.—Rich's Fire-indicating System.

*   *   *   *

Loud-speaking Telephones. To facilitate communication between the navigating stations and to provide a thoroughly efficient and reliable system of transmitting orders, a system of loud-speaking

telephones has been installed. The instruments are of the Graham patent type, as supplied in

Fig. 160.—Loud-speaking Telephone on Navigating Bridge.

all Admiralty vessels, and have been made by Messrs. Alfred Graham & Co., of London.

Three pillar telephones are fitted on the navigating bridge, of the design shown in Fig. 160. One of these communicates with a side-tube pattern navy telephone in the steering gear compartment. The second instrument, by means of a three-way combined switch and indicator, communicates with the apparatus at the forecastle head, the crow's nest, or the docking bridge aft. The third pillar telephone is fitted with a similar switching device, and communicates with special engine-room pattern telephones, as shown in Fig. 161, in the three turbine rooms.

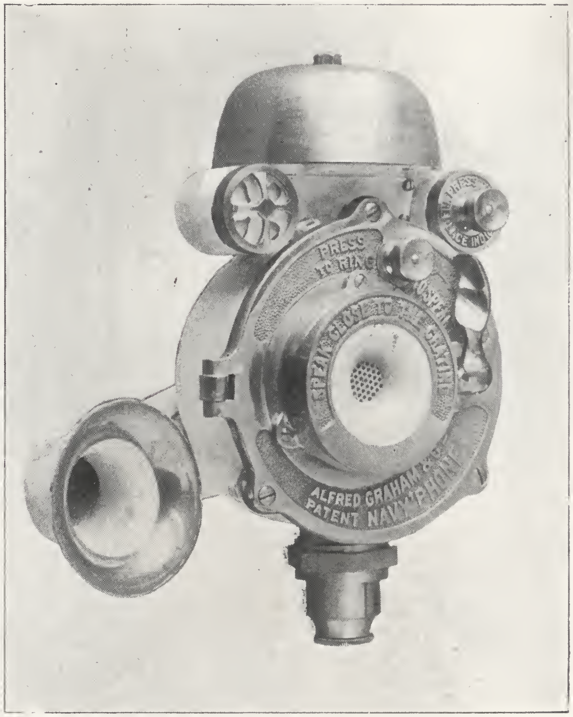


Fig. 161.—Loud-speaking Telephone, Engine Room Pattern.

Fig. 162.—Submarine Signalling System.

Officers and Crew.

OVER 800 persons will be employed on various duties on board the *Mauretania.* Of these, the greater number belong to the engineers' and the stewards' staff, the sailing staff being comparatively small. A complete list is given in the following table:—

Captain John Pritchard.

TABLE V.—OFFICERS AND CREW.

	No. of Persons.	
SAILING STAFF.		
Captain	1	
Officers	8	
Petty officers	15	
Seamen	40	
Carpenters	2	
Joiner...	1	
Marconi operators	2	
Doctor	1	
		70
ENGINEERS' STAFF.		
Chief engineer	1	
Engineers	29	
Refrigerating engineers	3	
Greasers	21	
Firemen	192	
Trimmers	120	
		366
PURSERS' STAFF.		
Pursers	3	
Chief steward	1	
Chef	1	
Leading stewards	4	
Matrons	2	
Cooks...	40	
Bakers	2	
Stewards	305	
Stewardesses	10	
Typists	2	
Mail sorters	3	
Barbers	2	
Inspector	1	
		376
Grand Total		812

Mr. John Currie.
(Chief Engineer.)

The captain's rooms are placed in the forward end of the deckhouse on the boat deck, immediately beneath the navigating bridge. The officers are berthed in a house on top of the sun deck, just behind the wheelhouse, and they have a messroom upon the shelter deck aft. The seamen and petty officers have rooms right forward upon the main and upper decks. The engineers' accommodation is situated upon the shelter deck, adjoining the engine casing. The firemen and trimmers are berthed on the main deck over No. 4 boiler room and the engine rooms. The doctor, pursers, chef and chief stewards have pleasant rooms situated amidships, in close proximity to the grand entrance. The stewards are mostly berthed aft, as may be seen from Plate VI.

Captain John Pritchard, who commands the *Mauretania*, is a native of Carnarvon, North Wales, and has been in the employ of the Cunard Co. for 28 years. During that period he has commanded most of the principal ships of the fleet, including the *Carmania*, *Caronia*, *Lucania*, *Campania*, *Etruria*, *Ivernia*, *Saxonia*, etc. It is an interesting fact that Captain Pritchard, twenty-nine years ago, took away the smallest ocean-going steamship ever built at Wallsend by Messrs. C. S. Swan & Co., as the firm was then constituted, and now he is in command of the largest vessel in the world. The *Princess of Wales*, as the small steamer was named, was 100ft. long B.P., by 17ft. 6in., by 9ft. 10½in. D.M. She carried 80 tons deadweight, and her gross tonnage was 96·31, so that the tonnage of Captain Pritchard's present command is more than 331 times greater than the little vessel launched in 1879.

The chief engineer, Mr. John Currie, is a native of Ayr, and has been in the Cunard service for many years. He has superintended the construction of the machinery, and afterwards sailed as chief engineer of such vessels as the *Caronia*, *Carmania*, etc., and is now repeating this order of things in the case of the *Mauretania*. He was in the *Lucania* when she made her record passages, so that the *Mauretania* could not have been placed in better hands for obtaining the best results. Mr. Currie was well known at Wallsend before the building of the *Mauretania*, as he superintended the construction of the machinery and sailed as chief engineer of the *Ivernia*, built by Swan, Hunter, & Wigham Richardson in 1900.

Departure from the Tyne, Dry-docking, and Trials.

Departure.

THE departure of the *Mauretania* from the Tyne presented a scene so animated and enthusiastic that it will not be readily forgotten by those who witnessed it. To the accompaniment of shrieks from the syrens of the numerous craft in the river and the roar of the "buzzers" of the shipyards and engine works, mingled with the cheers of tens of thousands of spectators who crowded every coigne of vantage on both sides of the river, the vessel left her berth at Wallsend on the afternoon of the 22nd October, with a distinguished company on board, and was towed without the slightest hitch to the open sea. Arriving at the mouth of the river about 80 minutes after leaving Wallsend, a halt was made to adjust compasses; and just as darkness was setting in, Mary, Lady Inverclyde, on the commander's bridge, gave the signal for the commencement of the first voyage. The historic occasion was not allowed to pass without the usual speech-making; and Mr. Thomas Bell (chairman of the Wallsend Slipway Company) presented her ladyship with a diamond bracelet as a souvenir of the event, Mr. G. B. Hunter also adding a few felicitous remarks.

During the voyage, a photograph, which we reproduce in Fig. 163, was taken of the men who have been largely concerned in the building of the vessel. Reading from left to right on the bottom row, the names are:—Colonel H. F. Swan, C.B., Mr. Andrew Laing and Mr. Thomas Bell (Wallsend Slipway Company), Mr. J. H. Beazley and Lord Inverclyde (Cunard Steamship Company), Mr. G. B. Hunter (Swan, Hunter, & Wigham Richardson), Sir William B. Forwood and Mr. M. H. Maxwell (Cunard Company), Mr. C. J. Leyland (Parsons Marine Steam Turbine Company), Mr. Wigham Richardson (Swan, Hunter, and Wigham Richardson), and Mr. James Bain (Cunard Company). Among others in the group are Captain Pritchard (commander of the *Mauretania*), Mr. W. Dranfield and Mr. L. Peskett (Cunard Company), Mr. C. G. Hall (Admiralty), Sir William H. White, K.C.B., Mr. C. S. Swan, Mr. T. H. Bainbridge, Mr. G. Ernest Hunter, Mr. G. B. Richardson, Mr. E. W. DeRusett and Mr. C. Stephenson (Swan, Hunter, & Wigham Richardson), and Mr. M. Murray, Mr. T. McPherson and Mr. G. Campbell (Wallsend Slipway Company).

After an exceedingly pleasant voyage, in ideal weather, accomplished at an average speed of about 22 knots, the vessel anchored off the Bar Lightship of the Mersey at six o'clock in the morning of the 24th October. About 9.30 a.m. the bar was crossed, and the vessel safely moored in the Canada Dock, Liverpool, previous to dry docking.

* * * *

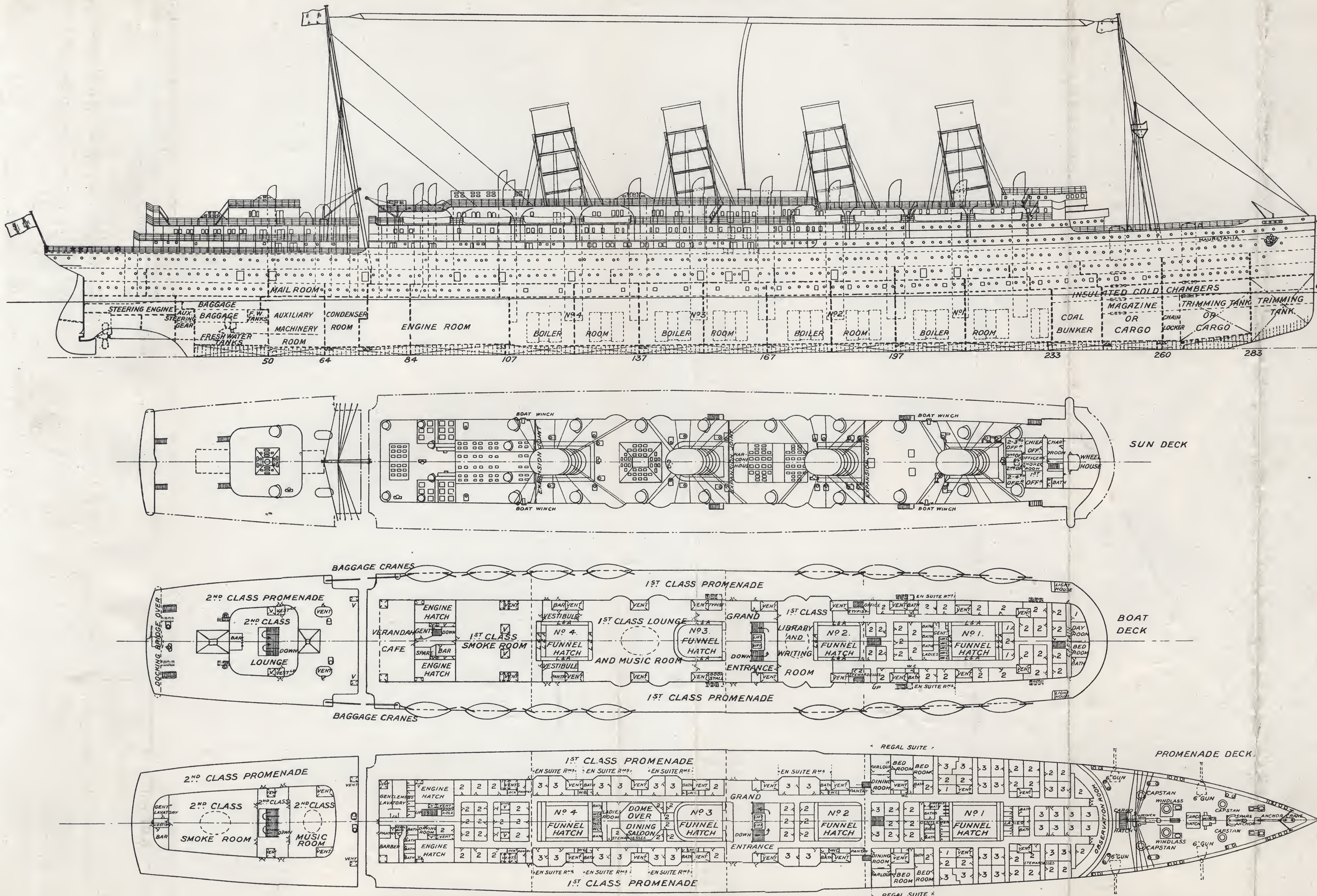
Dry Docking.

THE operation of dry docking called for a good deal of thought on the part of those concerned owing to the great docking weight of the ship, *viz.*, about 32,000 tons. The blocks in the Canada Graving Dock, where the vessel was docked on the 25th October, are of cast iron, spaced 2 feet 6 inches apart. Upon these blocks were placed 12-inch elm top blocks 4 feet long, and over these again there were two thicknesses of 3-inch soft wood packing, making 6 inches of soft wood in all. Near the ends of the vessel and under the machinery space, intermediate wood blocks were placed between the cast iron blocks, extending about 1 inch above the top of the latter, before docking. It was also considered desirable to fit a line of bilge blocks on each side of the centre in way of the midship boiler rooms, placed directly underneath the continuous longitudinal bunker bulkhead. The striking appearance of the vessel in dock is shown by our illustration, Fig. 164. Coming out of dry dock on the 30th October, she at once commenced coaling for her official trials.

Fig. 163.—Group taken on the Voyage to Liverpool.

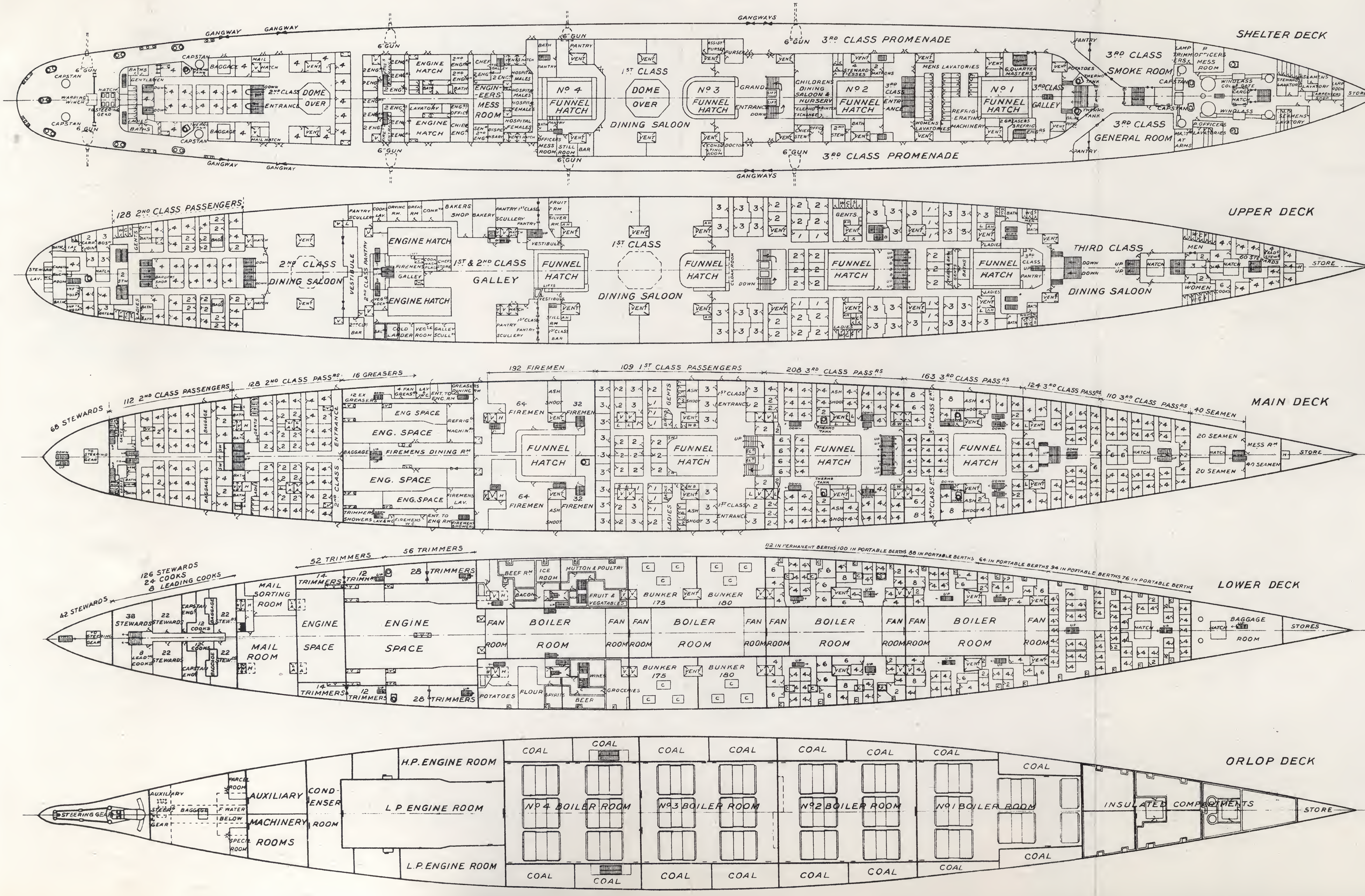
THE CUNARD EXPRESS LINER "MAURETANIA"

PROFILE AND DECK PLANS.



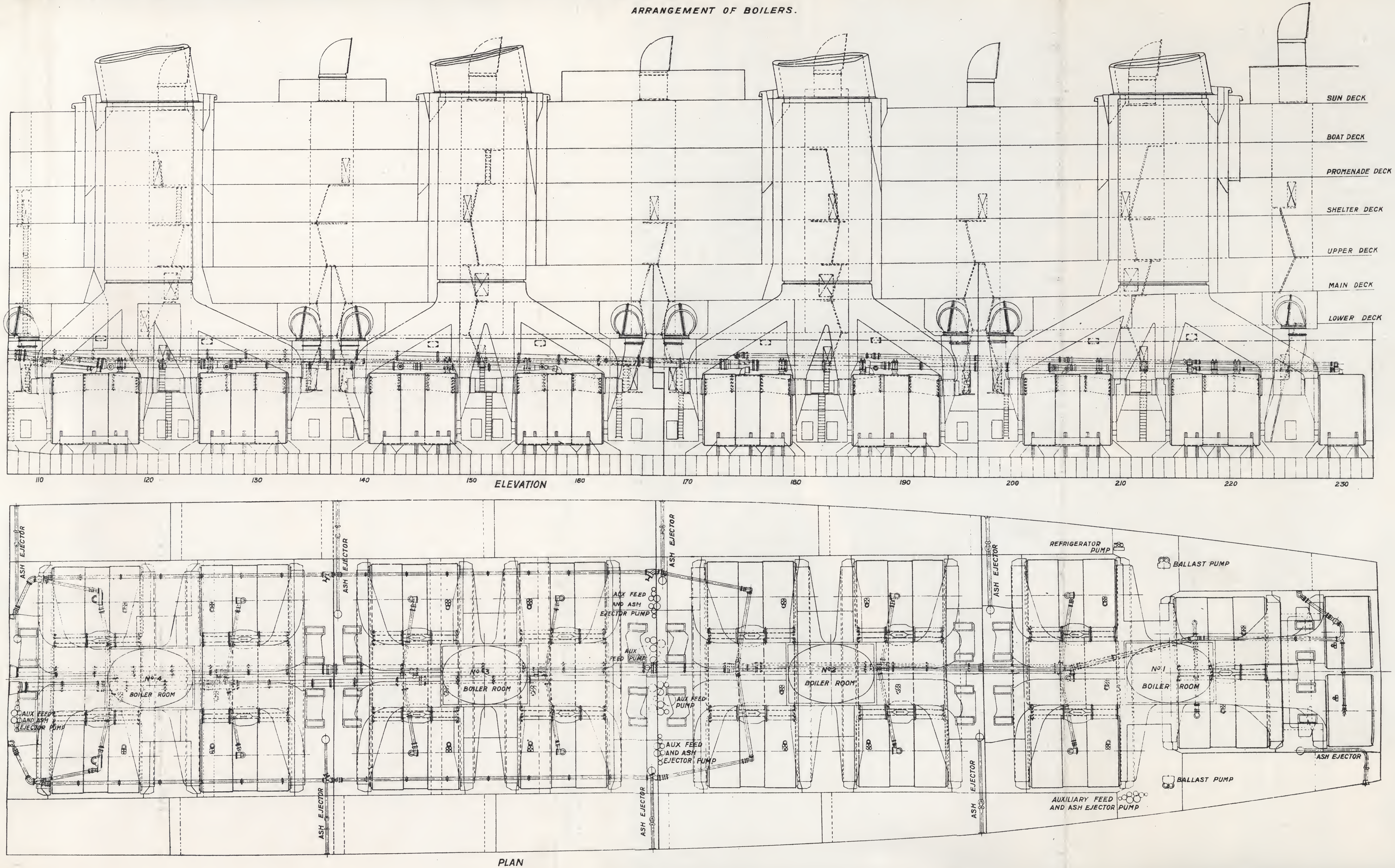
THE CUNARD EXPRESS LINER "MAURETANIA"

DECK PLANS.



THE CUNARD EXPRESS LINER "MAURETANIA".

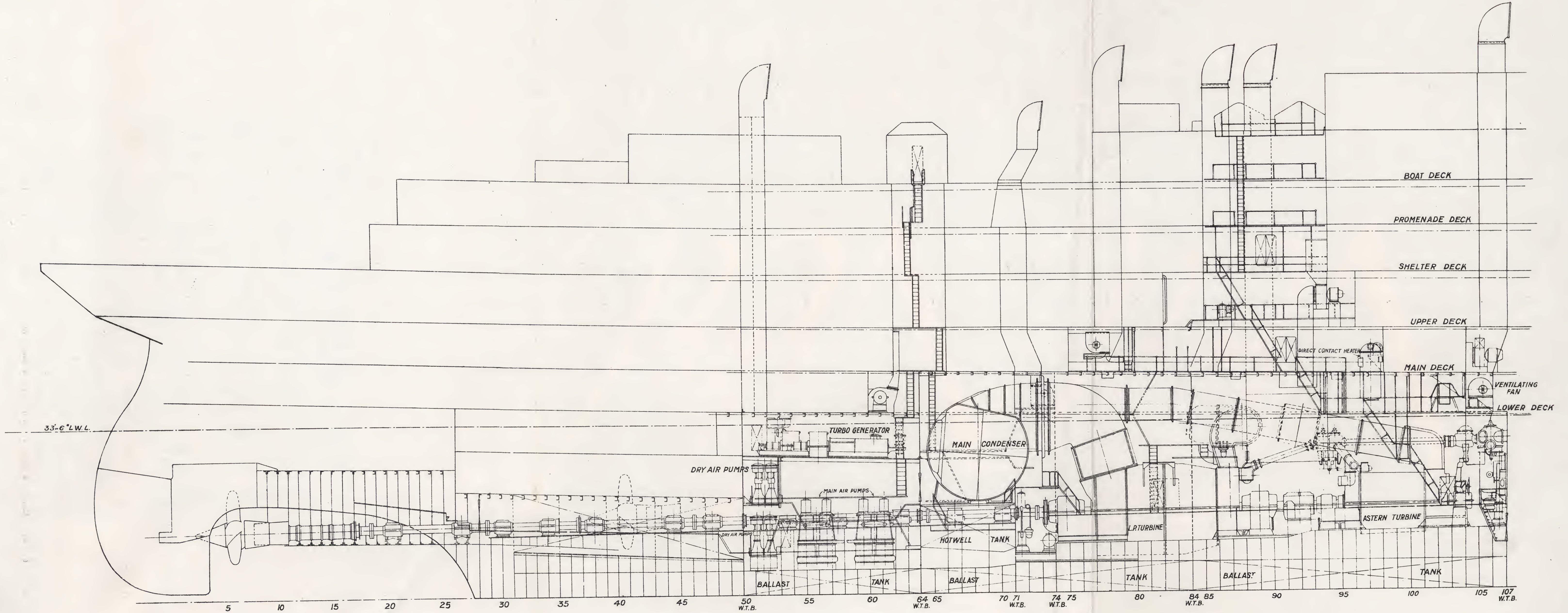
ARRANGEMENT OF BOILERS.



THE CUNARD EXPRESS LINER "MAURETANIA".

ARRANGEMENT OF MACHINERY.

ELEVATION



THE CUNARD EXPRESS LINER "MAURETANIA".

ARRANGEMENT OF MACHINERY.

PLAN

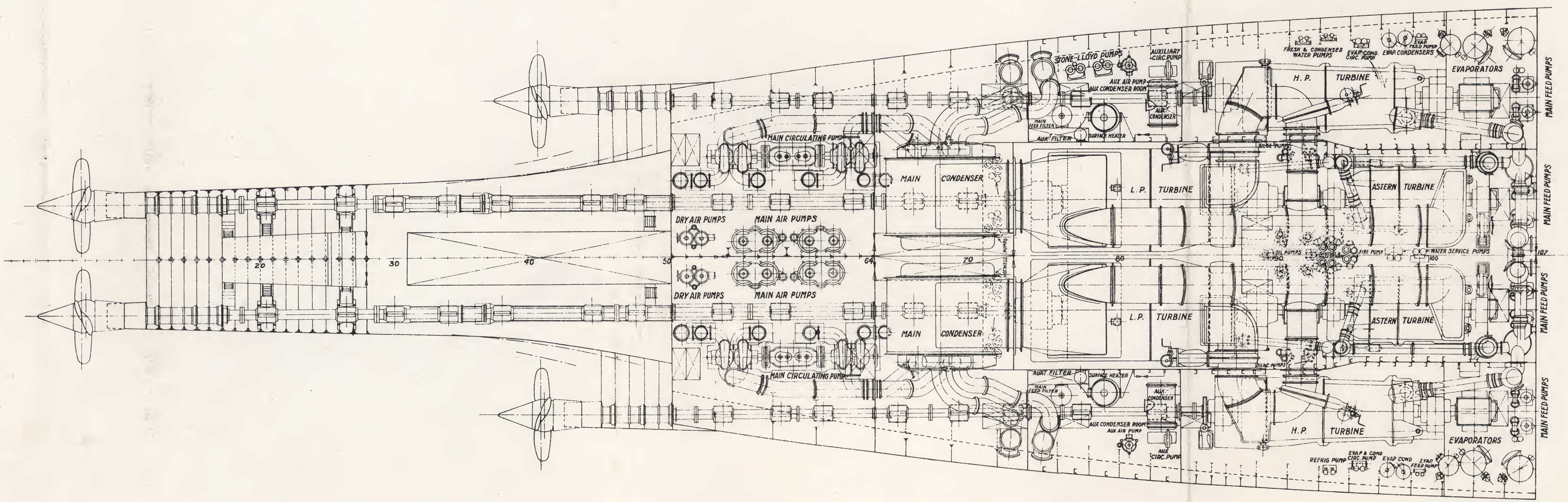


Fig. 164.—The "Mauretania" in Dry Dock.

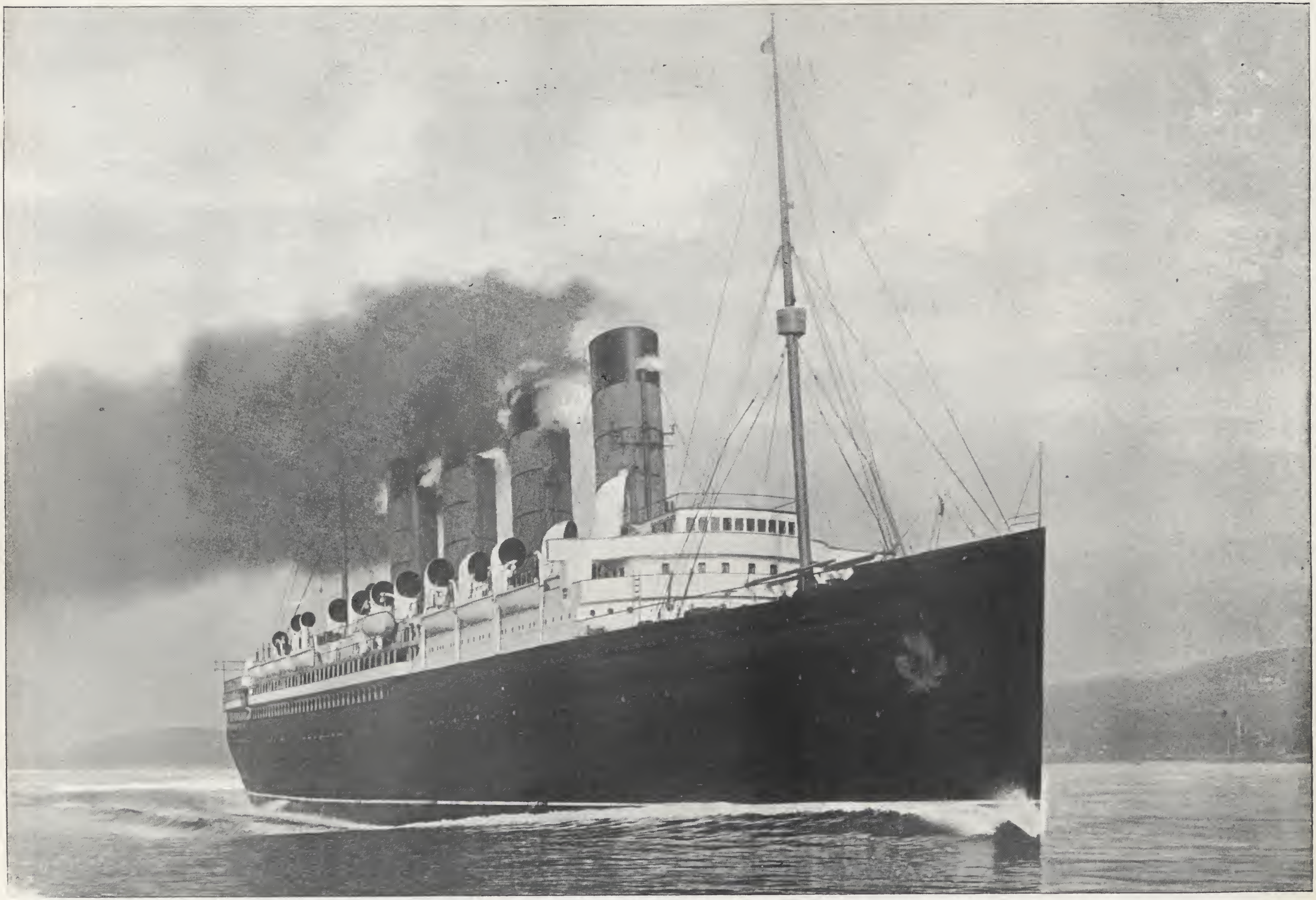


Photo by] **Fig. 165.—The "Mauretania" on the Measured Mile.** [*J. S. Dodds.*

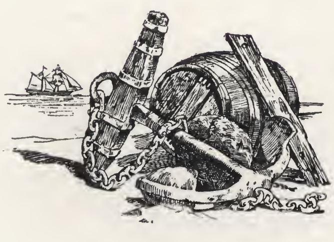
Official Trials.

The vessel left Liverpool on the morning of the 3rd November to commence her official trials, and, after a preliminary run North to Corsewall Point (Wigtownshire), entered upon the 48 hours' steaming trial at 8.0 o'clock in the evening. The course mapped out for this trial was from Corsewall Light to the Longships (Land's End), and was traversed by the vessel four times. The result achieved exceeded all expectations, a mean speed of 26·04 knots being maintained for the full distance. The speed maintained continuously at the loaded draught and under Atlantic conditions for a total distance of 1,200 knots easily breaks all past merchant ships' records, and is a remarkable performance. The speeds in the four different runs were as given below, no less than 27·36 knots being obtained on the second run South. On the first run South the vessel encountered a strong head wind, which materially retarded her progress:—

	Knots.
1st Run—Corsewall Point to Longships...	26·28
2nd ,, —Longships to Corsewall Point...	25·26
3rd ,, —Corsewall Point to Longships...	27·36
4th ,, —Longships to Corsewall Point...	25·26
Average speed over the trial...	26·04

After completing the long trial on the evening of the 5th, the vessel proceeded North and anchored off Wemyss Bay. On the 6th of November she proceeded to the measured mile at Skelmorlie, and progressive runs were made upon the measured mile to test the coal consumption. The ship maintained her reputation by achieving a speed of 26·75 knots on the best pair of runs; while later in the day, upon a long course between Ailsa Craig and Holy Island, a mean speed of 26·17 knots was obtained upon two consecutive runs. There is no doubt, therefore, that the vessel is capable of maintaining 26 knots over long distances, especially when the staff is more fully organised and experienced. After completing the runs between Ailsa Craig and Holy Island she was turned to the South and proceeded to Liverpool, arriving in the early morning of the 7th November.

The trials were in every way a success, being carried out with exceptional freedom from vibration; while all the auxiliary machinery and the various arrangements worked without a hitch. The shipbuilders and engine builders are to be congratulated upon producing a ship which, there is no doubt, will shortly capture the Atlantic record, not only for speed, but also for comfort, elegance and all-round efficiency.



General Index.

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(The largest Vessel in the World.)

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Edited by A. G. HOOD.

VOL. VI. MIDSUMMER, 1911. SPECIAL NUMBER.

The White Star Liners "Olympic" and "Titanic."

GENERAL INDEX.

Arkley
Newcastle Manors North

Mr. J. Bruce Ismay.
(Chairman and Managing Director of the White Star Line.)

The White Star Line.

THE completion of the immense liner *Olympic*, to be followed very shortly by the sister ship *Titanic*, the largest ships in the world, adds yet another triumph of shipbuilding and engineering skill to the splendid list of vessels built for the Atlantic passenger service. In no other trade have such remarkable developments taken place in the size of ships and in the comfort and luxury provided for passengers. Competition between the great shipping companies engaged has been very keen, and efforts to secure pre-eminence have been quickly followed by the endeavours of rival lines to "go one better." In this respect the White Star Line, or more properly the Oceanic Steam Navigation Company, has always been in the first rank since the Company was formed in 1869, and the building of the *Olympic* and *Titanic* makes it evident that the characteristic policy of enterprise and foresight is being worthily maintained.

Early History. The White Star flag was flown originally by a line of sailing vessels founded about 1850, and mainly engaged in the Australian trade to cope with the great rush to the newly found Australian goldfields. In 1867 the owner of this line retired and the fleet passed into the hands of the late Mr. Thomas Henry Ismay. Mr. Ismay commenced by introducing iron instead of wooden sailing ships; but having had some experience of steamships and Atlantic traffic as a director of the National Line, he realized the advantages to be obtained by the establishment of a high-class service of steamships in the Atlantic passenger trade, and in 1869 formed the Oceanic Steam Navigation Company for this purpose. In 1870 Mr. Ismay was joined in the management of this Company by Mr. William Imrie, the title of the managing firm being altered to Ismay, Imrie & Co. An order was immediately placed with Messrs. Harland and Wolff to build

Fig. 1.—The First "Oceanic," 1871.
(The Pioneer Steamship of the White Star Line.)

The Late Mr. Thomas H. Ismay.

(Founder of the White Star Line.)

a new fleet, thus commencing that connection between owners and builders which has been maintained with such marked success up to the present day, all the subsequent vessels of the White Star Line, with the exception of the *Cretic*, having been built at the famous Belfast yard.

The First "Oceanic."

The pioneer vessel of the new Line, the first *Oceanic*, was launched at Belfast in August, 1870, and arrived in the Mersey in February, 1871. She was 420 ft. long, 41 ft. broad, and 31 ft. deep, with a tonnage of 3,707, and she embodied a number of improvements previously unknown in the Atlantic trade. Her propelling machinery consisted of two sets of four-cylinder compound engines supplied by Messrs. Maudslay, Sons and Field, of London, working on a single shaft. Each set consisted of two 41-inch diameter high-pressure cylinders and two 78-in. diameter low-pressure cylinders, with a stroke of 60in. Steam was supplied by 12 boilers, having in all 24 furnaces, and working at 65lb. pressure. The speed of the vessel was about 14 knots with a coal consumption of 65 tons per day.

Notable Vessels.

Following the *Oceanic* came a long list of notable vessels, as will be seen from the diagram showing the progress of White Star steamers given in Fig. 2. Specially noteworthy were the *Britannic* and *Germanic*, built in 1874 and 1875. These vessels had a speed of over 16 knots, and reduced the time of passage to less than 7½ days. The *Germanic*, with new engines and boilers, made the passage in 6 days, 21 hours, 3 minutes, in August, 1896. No further development in the direction of high speed was attempted by the White Star Line until, in 1889, they placed on service the successful 20-knot vessels *Teutonic* and *Majestic*, their first twin-screw steamers, both of which, almost up to the advent of the *Olympic*, have been regularly employed between Southampton and New York, the *Teutonic* having been transferred to the Company's Canadian service from Liverpool in May last.

In 1899 an important stage was reached by the completion of the second *Oceanic*, a vessel surpassing in dimensions anything previously attempted and the first ship to exceed the *Great Eastern* in length. No attempt was made in her design, however, to emulate the high speed attained by the contemporary Cunard and German record breakers. It was considered that a speed of 20 knots was sufficient to make the vessel a reliable seven-day boat, and in this respect she has amply fulfilled expectations. Following the *Oceanic*, a return was made to slower speed vessels of 16 to 17 knots, but the increase in size was maintained. The largest vessel of the Line prior to the completion of the *Olympic* was the *Adriatic*, built in 1907, her dimensions being 709ft. 3in., by 75ft. 6in., by 56ft. 9in., and speed 17 knots. The completion of the *Olympic* and *Titanic* bring up the total number of White Star liners to thirty-one, having an aggregate gross tonnage of about 460,000.

DIAGRAM SHOWING COMPARATIVE SIZES OF VARIOUS TYPES OF WHITE STAR STEAMERS FROM 1871 TO THE PRESENT TIME

Length between Pers	420-0	350-0	437-6	370-0	455-0	430-0	440-0	420-0	430-0	585-0	460-0	470-0	490-0	500-0	558-7	475-9	585-6	550-2	685-6	680-9	500-3	600-7	550-3	582-0	578-3	475-10	708-5	709-3	550-0	850-0
Beam	41-0	35-2	41-0	36-3	45-2	42-0	44-[illegible]	42-4	45-2	57-8	49-1	53-1	53-2	60-3	60-3	55-2	64-3	63-3	68-6	75-0	63-3	65-6	59-3	60-2	59-3	55-2	75-4	75-6	67-0	92-0
Depth	31-6	25-6	31-6	27-6	33-6	31-6	31-6	29-6	28-8	39-4½	30-9	31-7	33-6	33-9	36-0	35-11	37-9	39-11	44-6	44-1	45-0	47-6	35-11	38-3	35-10	35-10	44-1	52-8	45-6	
Gross Tonnage	3807	2130	3888	2652	5004	4368	4748	[illegible]	4640	9984	5749	6583	7755	8301	10077	8273	13096	11948	17274	20904	12234	15801	11394	13518	12097	8194	23876	24541	14892	Est. 45000
Indicated Horse Power	1990	1500	3500	1800	4900	2000	3280	2800	3050	17500	3500	3700	4400	3700	4500	3000	6800	4800	28000	12600	4400	9800	8436	8000	8513	2170	14000	16000	12000	
Av. Speed Kn. per Hour	13·5	11·5	14·	11·5	15·	13·	13·	12·5	12·5	20·	13·	13·	13·5	13·	13·	11·	15·	13·	21·	17·	13·	16·	15	15·	15·	10½	16½	17·	17·	21
When Built	1871	1871	1872	1873	1874	1881	1883	1885	1888	1889	1891	1892	1893	1893	1895	1897	1898	1899	1899	1901	1901	1903	1903	1903	1903	1904	1904	1907	1909	1910

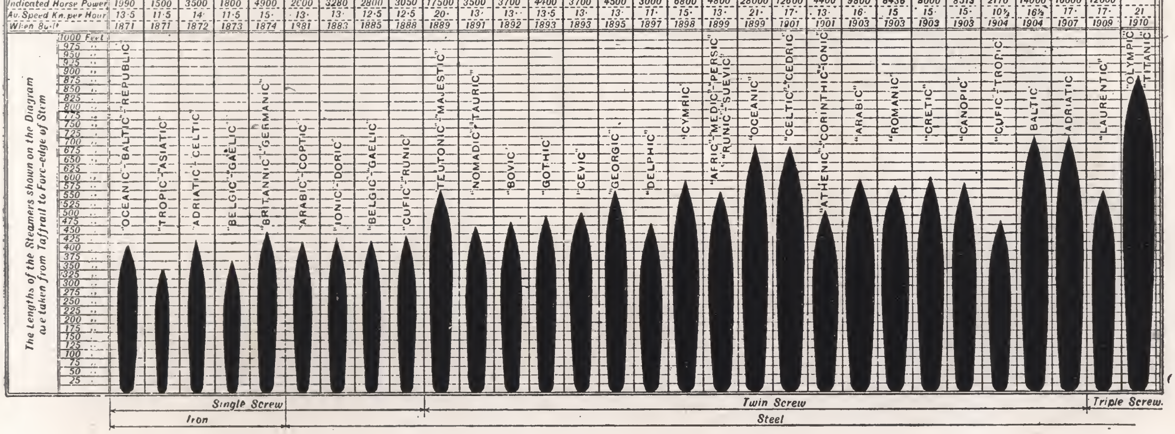


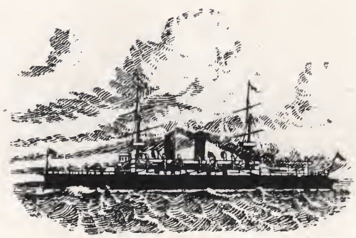
Fig. 2. —Diagram showing Development in Size of White Star Liners.

Later History.

Other notable events in the history of the Line have been the transference, in 1907, of the main service—Liverpool, Queenstown, and New York—to Southampton, Cherbourg, Queenstown, and New York, and the passage of its control to the International Mercantile Marine Company, of which the White Star Line forms the most important unit. In 1909 their first entry was made into Canadian traffic with the steamers *Laurentic* and *Megantic*, the largest vessels which have yet been employed in this service. The *Laurentic* and *Megantic* are further notable on account of the fact that whereas the *Megantic* is propelled with twin screws driven by reciprocating engines, the *Laurentic*, although otherwise of similar dimensions and form, is provided with triple screws and machinery combining two sets of reciprocating engines with a low-pressure Parsons turbine. This experiment was made in order that the relative merits of the two systems of propelling machinery could be ascertained. No results have been published regarding the performances of these ships, but the fact that it was decided to adopt the combined type of engines for the *Olympic* and *Titanic*, after the full experience of the two systems secured in this way, is significant.

Management.

The present chairman and managing director, Mr. Joseph Bruce Ismay, is the eldest son of the founder of the White Star Line, the late Mr. Thomas Ismay, and has occupied that position with great ability since the death of his father in 1899. Mr. Bruce Ismay was born in 1862. He was educated at Harrow and then served a seven years' apprenticeship in the office of Messrs. Ismay, Imrie & Co., after which he proceeded to New York as agent for the White Star Line. Returning later to Liverpool, he was admitted a partner in the firm. Training and temperament alike have combined to fit Mr. Ismay eminently for the position of vast responsibility he holds, and the success of the *Olympic* is in no small measure due to the interest and initiative he has displayed in dealing with the many problems involved. Associated with Mr. Ismay in this work mention should be made of those officials of the Line who have devoted great ability and untiring energy to the mass of detail connected with the building of the two latest and greatest Atlantic liners.



The Builders of the "Olympic" and "Titanic."

THE builders of the *Olympic* and *Titanic*, the celebrated firm of Harland & Wolff, Limited, have had unrivalled experience in the construction of large passenger vessels, and the new White Star liners but add another triumph to the many which they have to their credit. Unlike many shipbuilding firms, Messrs. Harland & Wolff may be termed builders in the most complete sense of the word. As in the case of all vessels built by them, not only have they constructed the hulls of the *Olympic* and *Titanic*, but also their propelling machinery, while much of the outfit usually supplied by sub-contractors for ships built in other yards has been manufactured in their own works.

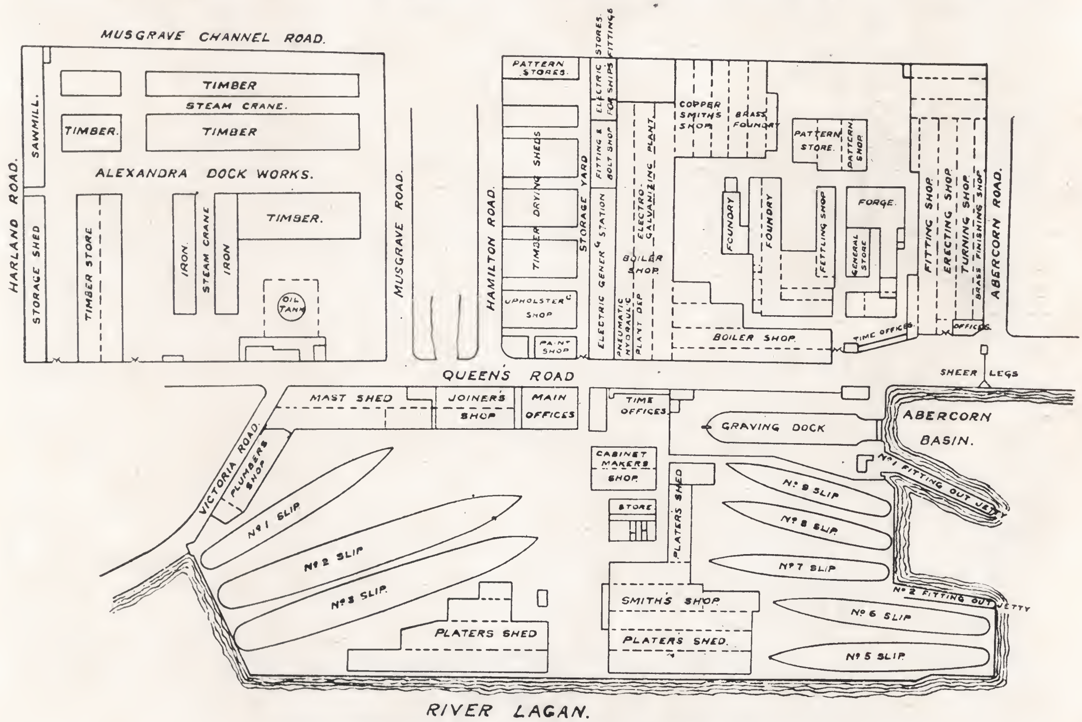
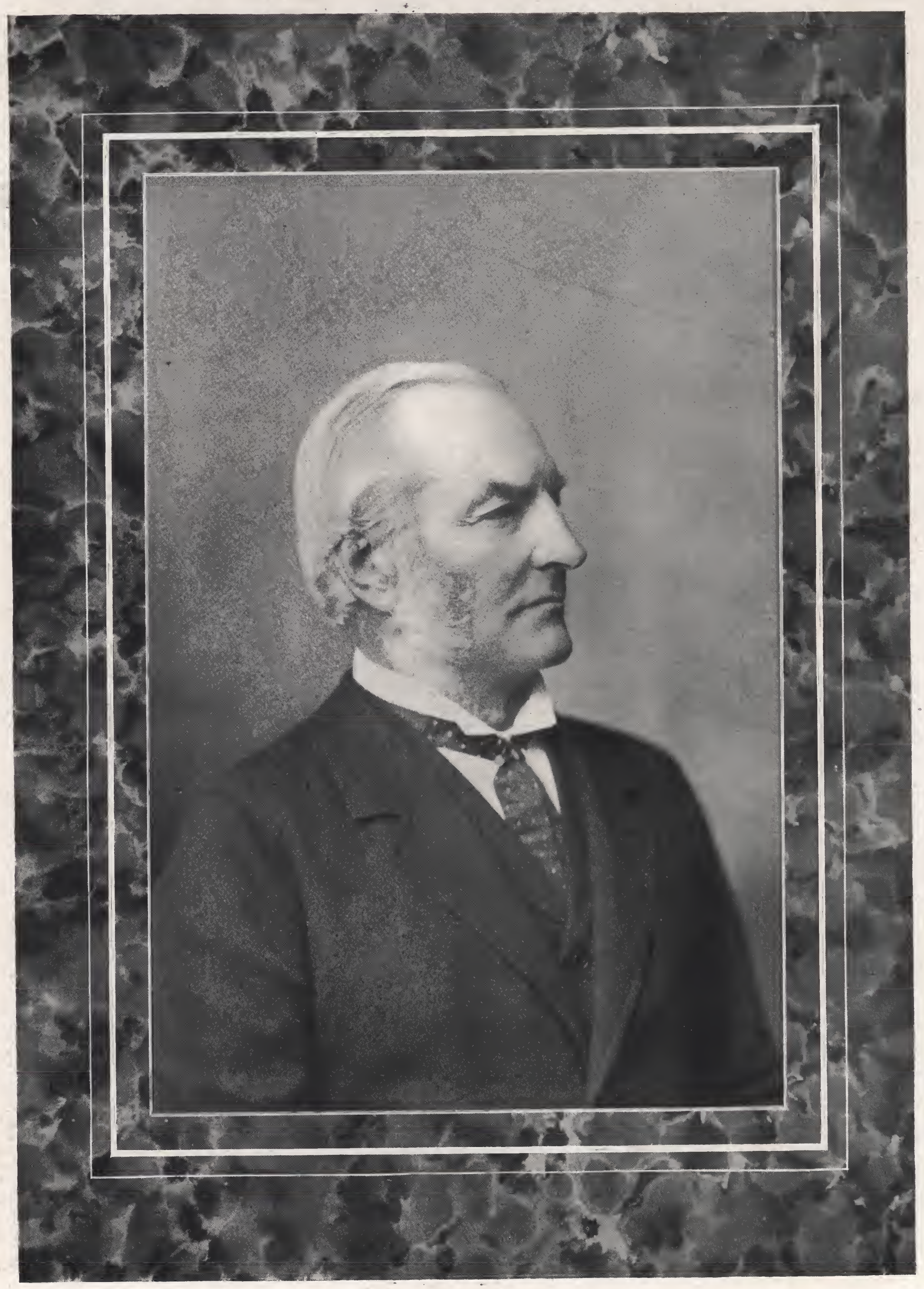


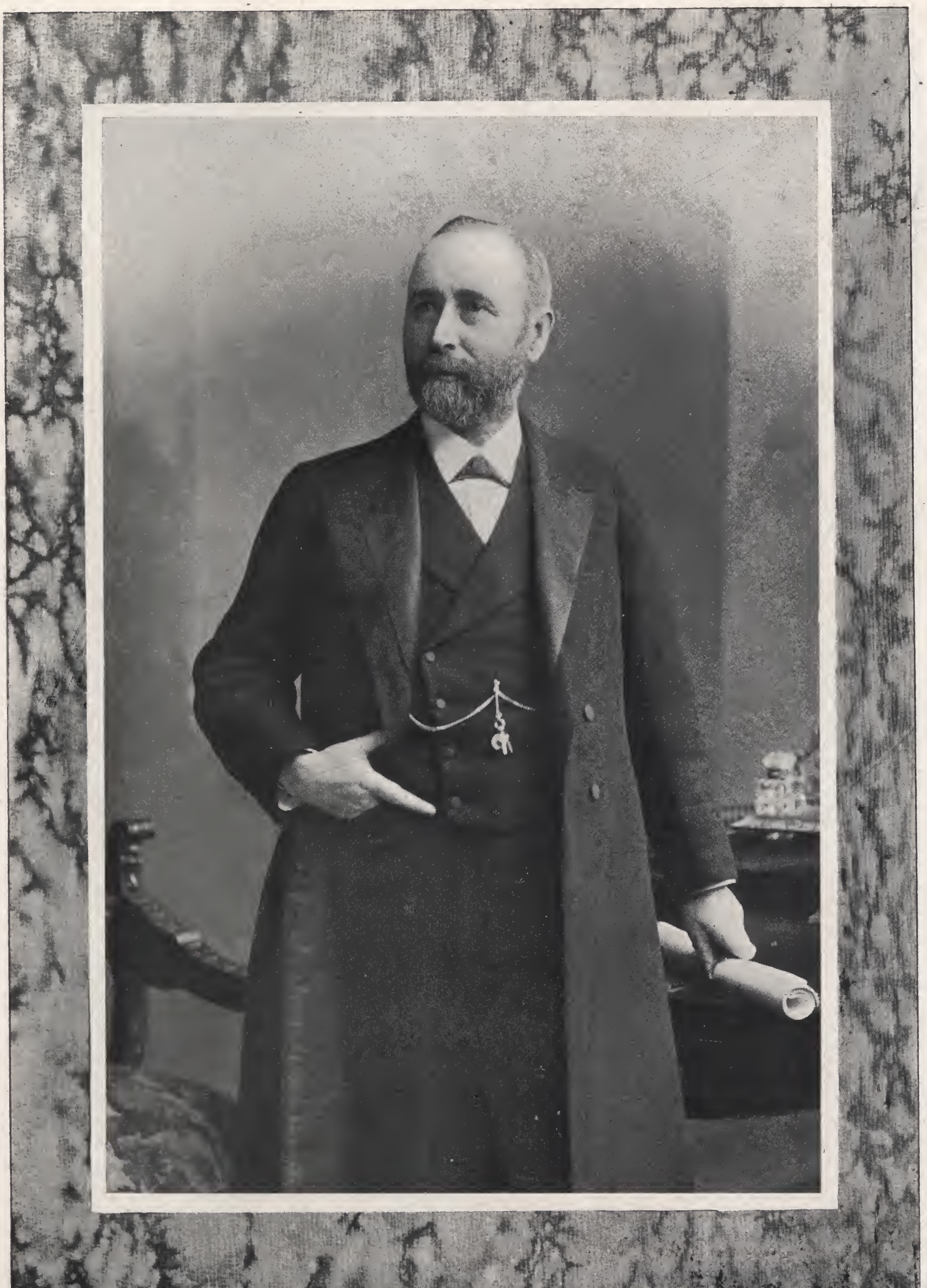
Fig. 3.—Plan of the Queen's Island Works.

Early History. The magnificent shipbuilding yards and works existing at Queen's Island to-day afford little indication of their humble beginning at the middle of the last century. The site upon which they stand is in reality artificial land, reclaimed by the Belfast port authority during the years 1841-6 while the straight cut to Belfast Lough and the sea, known as the Victoria Channel, was in course of construction. A portion of this ground was enclosed for a shipyard by the Harbour Commissioners in 1847, and was first leased to the firm of Robert Hickson & Co., who commenced to build iron sailing ships there in 1853. To this firm Mr. (afterwards Sir) Edward James Harland came from the Tyne as manager in 1854, when only twenty-three years of age. At first he encountered great difficulties both with the workmen and with the financial affairs of the firm, difficulties which would have daunted a man less determined; but Mr. Harland was no ordinary man, and his personality triumphed over all obstacles.

In 1859 Mr. Hickson retired, and Mr. Harland, with the financial assistance of a friend, Mr. G. C. Schwabe, of Liverpool, acquired the yard on his own account. His first contract was for three steamers for the Bibby Line, each 270ft. long, by 34ft. wide, by 22ft. 9in. deep, a large order for those days. Thus commenced a business connection which has lasted until the



The Late Sir Edward J. Harland, Bart.



The Right Hon. Lord Pirrie, P.C., LL.D., D.Sc., D.L.

Pirrie

Fig. 4.—General View of Gantry over Slips Nos. 2 and 3.

present time, for the latest Bibby liner, the *Gloucestershire*, a fine vessel of about 8,100 tons gross, left Belfast the day after the *Olympic* was launched. The drawing office was placed in charge of Mr. G. W. Wolff, who later was taken into partnership, the firm from the 1st January, 1862, being known as Harland & Wolff. The business prospered exceedingly, the energy and enterprise of the partners, together with the high class work turned out, gradually building up the great reputation which the firm ultimately acquired.

Lord Pirrie.

In 1874 Mr. W. J. Pirrie (who was raised to the peerage in 1906) was admitted a partner. In 1895 Sir Edward Harland died, in 1906 Mr. Wolff retired, and Lord Pirrie has remained in supreme control, worthily maintaining the traditions of the firm. The business was turned into a private limited liability company in 1885, the capital being £600,000, divided into six hundred shares of £1,000 each.

Lord Pirrie's career, which has already been the subject of a special article in *The Shipbuilder*,* has been one of the most notable among those of the great captains of industry. Entering the Queen's Island yard in 1862 as an apprentice at the comparatively early age of fifteen, he became successively draughtsman, assistant manager, sub-manager, works manager, partner, and ultimately chairman of Harland and Wolff, Limited. His activities have not been confined to shipbuilding, and his business abilities have secured for him the chairmanship of several leading shipping companies, besides directorships in numerous large industrial concerns.

Associated with Lord Pirrie in the management of the Queen's Island establishment are five directors, each having his own special department to control.

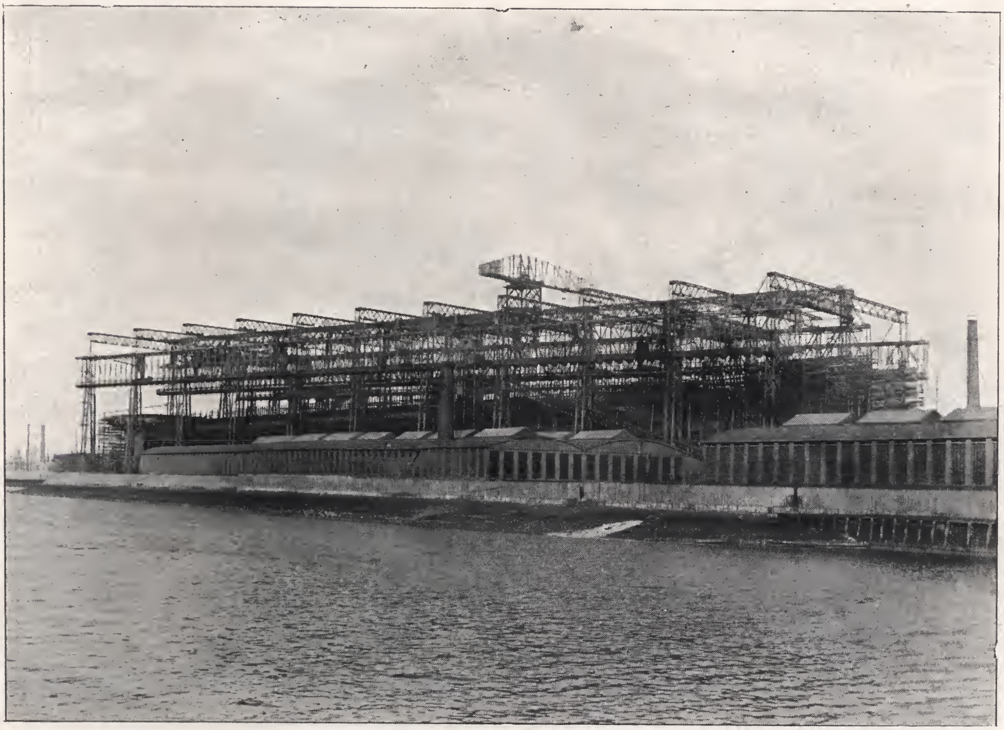


Fig. 5.—*Side View of Gantry over Slips Nos. 2 and 3.*

The Present Works.

The present Works are very extensive and employ over 14,000 men. Their extent and arrangement are shown in Fig. 3. It will be seen that there are no less than eight building slips, all capable of taking large vessels. Nos. 2 and 3 slips were specially laid out for the construction of the new White Star liners in the place previously occupied by three slips, the great increase in the size of the two vessels necssitating a reduction in the number of berths. The ground in way of the

* No. 7, Vol. II., 1908.

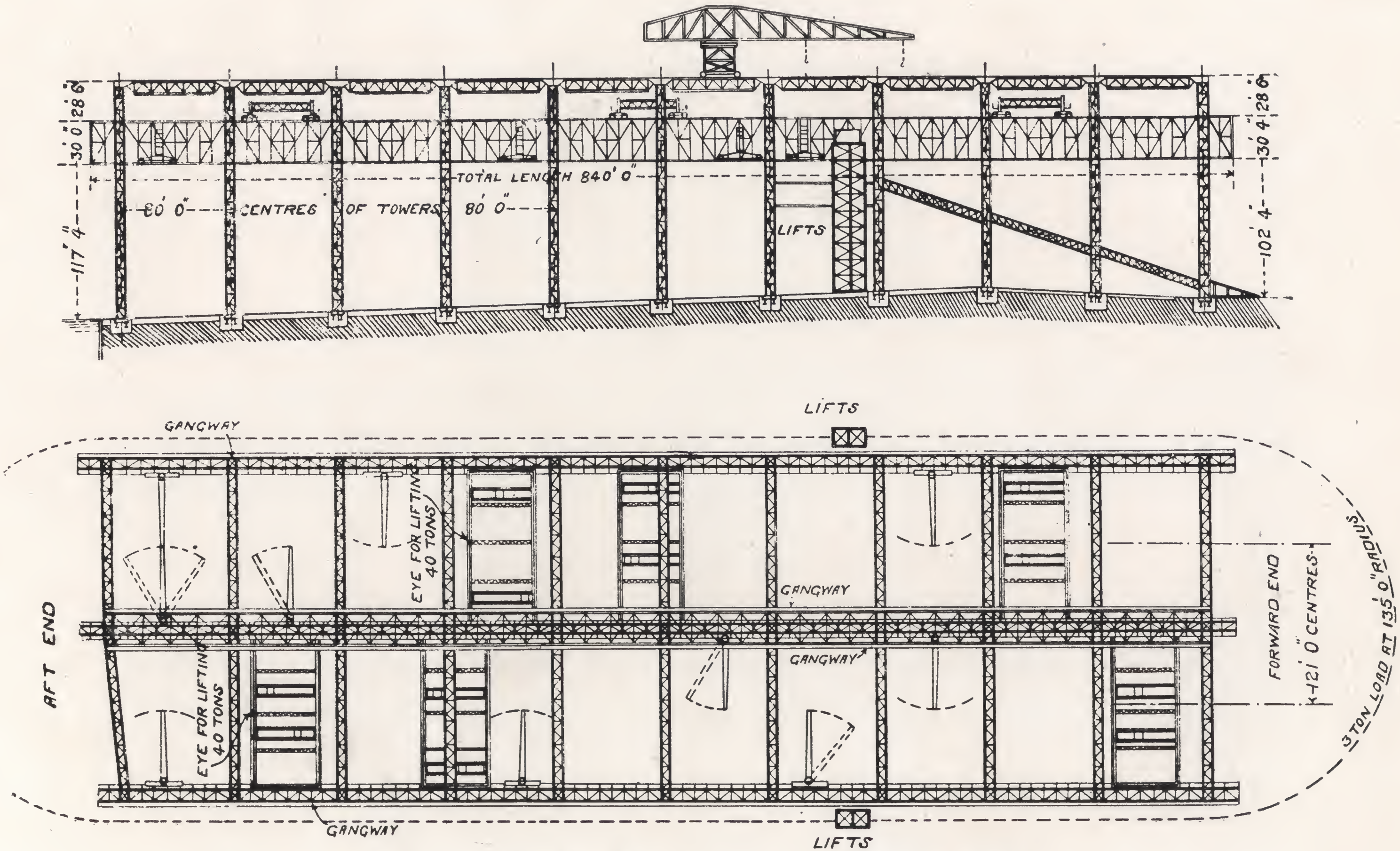


Fig. 6.—Elevation and Plan of Gantry over Slips Nos. 2 and 3.

new slips was piled throughout and covered with concrete, in some places as much as 4ft. 6in. thick, reinforced by a framework of steel. The floor of the berths is laid at $\frac{3}{8}$in. per foot declivity.

Shipyard Crane Equipment.

Over the new slip berths was erected the remarkable structure, illustrated by Figs. 4, 5, 6, & 7, for carrying the cranes necessary for the economical erection and hy-

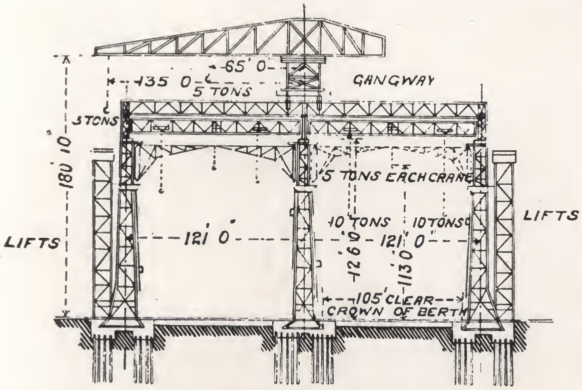


Fig. 7.—Section of Gantry over Slips Nos. 2 and 3.

draulic riveting of such large vessels. It is difficult to realize the size of this structure from illustrations only, or indeed when closely inspecting it from the ground; it is only when looking down on the surrounding buildings from the topmost girders that its true proportions become apparent. It consists of three rows of towers spaced 121 feet between the rows, centre to centre, each row containing eleven towers spaced 80 feet centre to centre. The towers at their base are about 21 feet by 9 feet, and are fixed in solid concrete foundations resting upon 40-feet piles. At their extreme top the towers are connected by girders across the berths, and at a lower level by fore and aft girders, which provide a path for the various cranes. Access to the upper parts of the structure and ships under construction is provided by four large electric lifts. The area covered exceeds 840 feet long by 270 feet wide.

The crane equipment of Nos. 2 and 3 slips consists of the following:—(1) A central cantilever revolving crane, mounted on a girder path over the centre row of columns, and capable of lifting three tons at 135 feet, or five tons at 65 feet; (2) ten walking cranes, each lifting five tons, three being placed on the inside of each of the outer rows of towers and two on each side of the centre row of towers; and (3) six travelling frames, three over each berth, each frame carrying two travelling cranes capable of lifting ten tons. The total height of the structure from the ground at slip level to the top of upper crane is no less than 228 feet. The weight of the entire structure and equipment is upwards of 6,000 tons.

The remaining crane equipment of the building berths consists of three travelling gantries

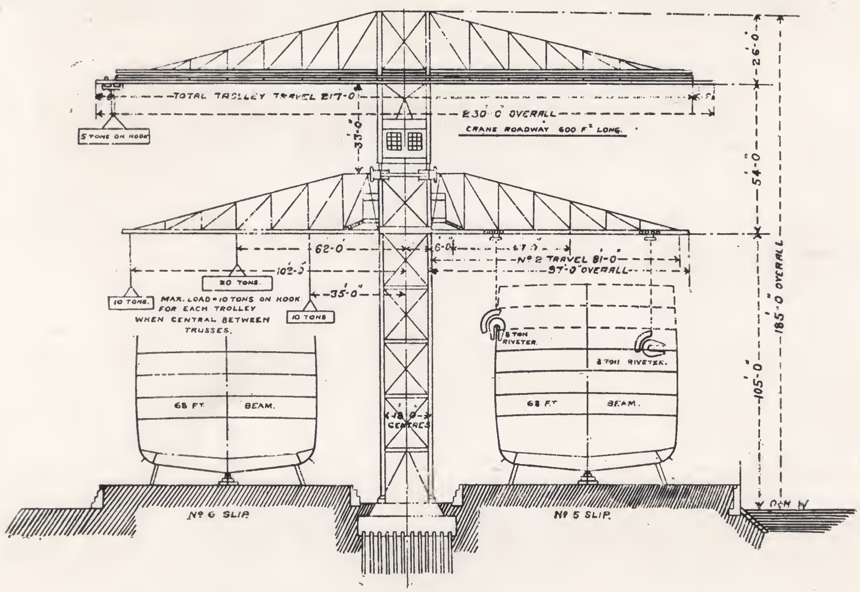


Fig. 8.—Section of Gantry over Slips Nos. 5 and 6.

Fig. 9.—A Portion of one of the Platers' Sheds.

Fig. 10.—The Mould Loft.

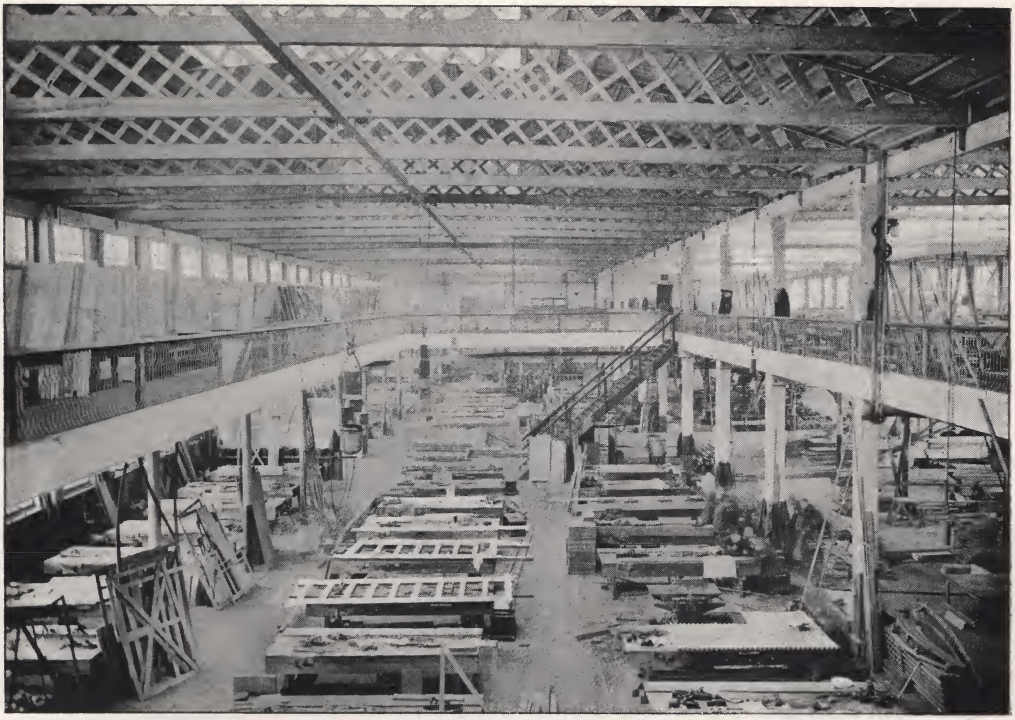


Fig. 11.—A Portion of the Joiners' Shop.

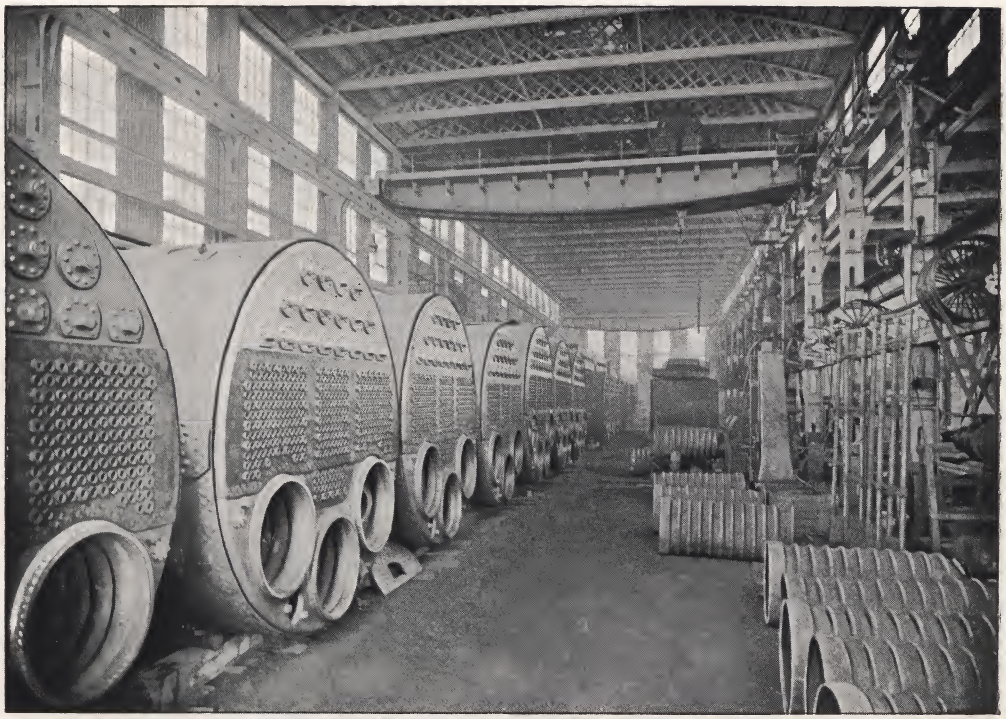


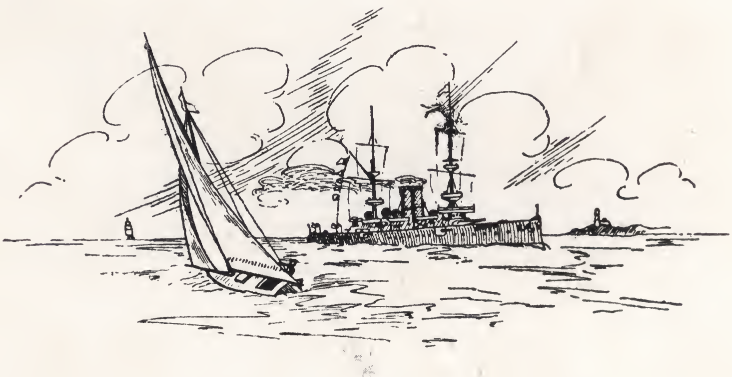
Fig. 12.—A Portion of the Boiler Shop.

with cranes over No. 1 slip; a gantry of the Brown electric type between Nos. 5 and 6 slips on the other side of the yard (see Fig. 8), which has been in successful operation for some years; and revolving jib cranes, mounted on steel derrick pillars, between berths Nos. 7, 8, and 9.

Workshops. Electric power and light are supplied to the whole of the works from the firm's own magnificent power station, which has a capacity of no less than 4,000 kilowatts and close upon 7,000 indicated horse-power, the connected motor load exceeding 10,000 horse-power, while for arc lighting alone 1,500 additional horse-power is required. In order to deal with the ironwork of the largest vessels, the platers' shed (Fig. 9), adjoining slips Nos. 2 and 3, was largely remodelled and equipped with the most up-to-date machines while the slips were under re-construction, and here most of the ironwork of the *Olympic* and *Titanic* has been prepared. The mould loft, in which the sections of a vessel are laid down to full size and moulds prepared for the workmen, is illustrated by Fig. 10.

In joinerwork—one of the most important items in a large passenger vessel—Messrs. Harland & Wolff stand unsurpassed, and possess admirable facilities for dealing with all classes of vessels. The large joiners' shop is shown in Fig. 11. The same remark regarding facilities also applies to the engineering section of the works, which is exceedingly well arranged. One of the most important shops is the boiler shop (Fig. 12), which is 820 feet long by 160 feet broad, with a wing 455 feet long by 90 feet broad. Adjoining the engine works is the quay at which vessels lie while their machinery is being put on board. In the case of the *Olympic* and *Titanic*, however, owing to their size, this berth could not be utilized, and the machinery was put on board the ships by the 200-ton floating crane owned by the firm.

It will be evident from this brief description how completely equipped the Queen's Island establishment is for dealing with the construction of the two immense vessels for the White Star Line.



Evolution of the Design.

THE evolution of the Atlantic liner of to-day has been one of the most remarkable achievements in the scientific progress and commercial activity of modern times. It is difficult to realize that only 73 years have elapsed since the Atlantic was first crossed by a vessel continuously under steam power. This pioneer steamer, the *Sirius* (Fig. 13), was a small wooden paddle steamer 208ft. long overall and 178ft. along the keel. Her breadth was 25ft. and depth of hold 18ft. Upon her first Transatlantic voyage, in April, 1838, she carried 94 passengers and averaged about $7\frac{1}{2}$ knots speed. What a contrast to the present-day *Kronprinzessin Cecilie*, *La France*, *Lusitania*, *Mauretania*, *Olympic*, and *Titanic*, to mention but the most celebrated of recent ships !

It is impossible in the short space of this article to trace all the stages of development from the *Sirius* to the two latest White Star liners, and only the most important facts can be mentioned. The increase in size and speed has been continuous, as will be seen from Table I. giving the particulars of notable Atlantic liners, and also from Fig. 2 showing the development of White Star ships. The use of wood as the material for construction of the hulls was followed by the introduction of iron, which in turn was superseded by steel. Paddle wheels as a means of propulsion were abandoned in favour of the screw propeller driven by reciprocating engines. The reciprocating engine developed from the compound to the triple, and later to the quadruple-expansion type, two sets of engines, driving twin screws, being adopted as larger powers were required. The highest perfection of this type of engine was reached in the German record breakers *Kaiser Wilhelm II.* and *Kronprinzessin Cecilie*, which have twin screws and four sets of engines, two sets being mounted on each shaft.

Fig. 13.—The "Sirius" (1838).

Turbine propelling machinery in conjunction with triple screws appeared on the Atlantic in 1904, when the Allan liners *Victorian* and *Virginian* entered upon service, and was also adopted for the Cunard liner *Carmania*, completed in 1906. The greatest triumphs of the turbine have been won by the quadruple-screw express Cunarders *Lusitania* and *Mauretania*, which now hold all the Atlantic speed records. But although the turbine has been eminently successful for the high-speed ship, at more moderate speeds its economy is not so marked, a fact which has led to the introduction of the latest type of propelling machinery, the combination of reciprocating engines with a low-pressure turbine. When considering the type of machinery to be adopted for the *Olympic* and *Titanic*, the White Star Line and Messrs. Harland and Wolff, as already mentioned, agreed to test the merits of the combination system compared with reciprocating engines of the ordinary type by building two vessels exactly similar except in regard to propelling machinery. These two vessels, the *Megantic*, fitted with reciprocating engines, and the *Laurentic*, fitted with combination engines, were completed in 1909. Their relative performances in the White Star Line's Canadian service completely justified the expectation regarding the superior economy of the combined type of machinery, and it was decided to adopt combined engines for the later and much larger vessels.

Factors of Design.

It may not be out of place at this stage to briefly indicate the many problems which beset the designer of an Atlantic liner and the main considerations determining the dimensions, form, and arrangement of ships like the *Olympic* and *Titanic* which are intended to eclipse earlier vessels. The two most important factors of design are the speed and passenger accommodation to be aimed at, and it has always been the endeavour of the competing steamship companies on the Atlantic to possess vessels which excel in one or both of these respects. Both factors are favoured by increase in size of ship ; hence the tendency to greater dimensions

which has been so marked during the past few years. The maximum possible dimensions of a new vessel depend upon the dock and harbour accommodation available when the ship is completed; and it is for this reason that Lord Pirrie, among others, has devoted so much time and energy to the question of increased dock and harbour facilities.

Reverting to the subject of speed, high speed is a very costly requirement, not only owing to the great initial cost of the propelling machinery and the heavy cost of fuel on service, but also on account of the necessary fineness of the ship, which limits the earning power as regards cargo-carrying and the extent of passenger accommodation. In a high-speed Atlantic liner, the difficulties of design are greatly increased, as the designer is handicapped by the limited draught of water available at the terminal ports, and very careful consideration has to be given to the question of weight, any saving which can be effected being of great value. If, on the other hand, a more moderate speed is aimed at, the problem of weight is much simplified, as the vessel can be built to a fuller model and a greater displacement secured, without exceeding the draught available. It has been the custom of the White Star Line to strive for pre-eminence in passenger accommodation in conjunction with a speed which can be obtained without too great a sacrifice of cargo capacity, and the *Olympic* and *Titanic* have been designed in accordance with that policy. Although a passenger on one of these vessels will not have the honour of crossing in the fastest ship on the Atlantic, he will have many compensating advantages as regards increased comfort at sea and the greater extent and variety of the accommodation provided.

Other matters which require the careful consideration of the designer are the problems of strength, stability, and behaviour at sea. The subject of the strength of an Atlantic liner was ably dealt with by Professor J. Meuwissen in a former special number of *The Shipbuilder*,* and those interested in the technical aspect of the question are referred to that article. As regards stability, while the metacentric height must be sufficient to prevent the vessel taking an unpleasant list when subjected to a beam wind, it should be kept within moderate limits to ensure easy rolling in a seaway. Metacentric heights of from 1ft. 6in. to 2ft. 6in. have been found satisfactory in this respect. Close attention must also be given to the problems connected with water-tight subdivision, steering, ventilation, heating, electrical equipment, and the hundred and one items which go to make the complete ship and the magnitude of which will be better realized by the general public from a perusal of the following pages. Enough has been said, however, to indicate that the task of the naval architect in the production of two such vessels as the *Olympic* and *Titanic* is no light one. Indeed the design and construction of these two magnificent ships would have been beyond the range of possibility but for the cumulative experience available from earlier efforts during the past half-century.

Table I.—Large Atlantic Liners.

Name.	Builders.	Date.	Length.	Beam.	Depth.	Draught.	Displacement.	Gross Tonnage	Engines.	I.H.P.	Speed.
			Ft.	Ft. in.	Ft. in.	Ft. In.	Tons.				Knots.
Great Eastern ...	Scott Russell	1858	680	83 0	57 6	25 6	27000	24360	Pad. & Sc.	7650	14·5
Paris and *New York*...	Clydebank Works	1888	528	63 0	41 10	23 0	13000	10499	Recipg.	20600	21·8
Teutonic and *Majestic*..	Harland & Wolff	1890	565	57 6	42 2	22 0	12000	9686	Do.	19500	21·0
Fürst Bismarck ...	Vulcan Co., Stettin	1891	503	57 3	38 0	22 6	10200	8000	Do.	16412	20·7
Campania and *Lucania*	Fairfield Co.	1893	600	65 0	41 6	23 0	18000	12500	Do.	30000	22·01
St. Louis and *St. Paul*..	Cramp, Phil., U.S.A	1895	536	63 0	42 0	26 0	16000	11629	Do.	18000	21·08
Kaiser Wilhelm der Grosse	Vulcan Co., Stettin	1897	625	66 0	43 0	28 0	20880	14349	Do.	30000	22·5
Oceanic	Harland & Wolff	1899	685	68 5	49 0	32 6	28500	17274	Do.	27000	20·72
Deutschland... ...	Vulcan Co., Stettin	1900	662·9	67 0	44 0	29 0	23620	16502	Do.	36000	23·5
Kronprinz Wilhelm ...	Do.	1901	663 o. a.	66 0	43 0	29 0	21300	14908	Do.	36000	23·5
Kaiser Wilhelm II. ...	Do.	1903	678	72 0	52 6	29 0	26000	19361	Do.	38000	23·5
La Provence... ...	Chantiers de Penhoët, St. Nazaire	1906	597	64 7½	41 8	26 9	19160	13750	Do.	30000	22·05
Kronprinzessin Cecilie	Vulcan Co., Stettin	1907	678	72 0	52 6	29 0	26000	19400	Do.	38000	23·5
Adriatic	Harland & Wolff	1907	709	75 6	56 9	...	40790	24541	Do.	16000	17
Lusitania	Clydebank Works	1907	760	88 0	60 0	...	44060	30822	Turbines	70000	25·5
Mauretania	Swan, Hunter, & Wigham Richardson, Ld.	1907	760	88 0	60 6	...	44640	31938	Do.	70000	26·0
La France	Chantiers de Penhoët, St. Nazaire	1911	685	75 5	52 10	29 6	27000	23000	Do.	45000	23·5
Olympic and *Titanic*...	Harland & Wolff	1911	850	92 0	64 3	...	60000	45000	Recipg. & Turbine	46000	21

* "Mauretania" Number, 1907.

Building of the Hulls.

THE following are the leading sizes of the *Olympic* and *Titanic* as constructed:—

TABLE II.—DIMENSIONS.

Length over all	882′ 9″
Length between perpendiculars	850′ 0″
Breadth extreme	92′ 6″
Depth moulded to shelter deck	64′ 3″
Depth moulded to bridge deck	73′ 3″
Total height from keel to navigating bridge	104′ 0″
Load draught	34′ 6″
Gross tonnage	45,000
Indicated horse-power of reciprocating engines	30,000
Shaft horse-power of turbine engine..	16,000

A comparison of the foregoing information with the table of dimensions of other vessels given in the preceding chapter will show that the *Great Eastern* was 170 feet shorter and 20,600 gross tons less; the *Kaiser Wilhelm II.* and the *Kronprinzessin Cecile* are each 172 feet shorter and 25,600 tons less; the *Adriatic* 141 feet shorter and 20,500 tons less; and the *Mauretania* 90 feet shorter and about 13,000 tons less.

Structural Design.

THE structural design of the *Olympic* and *Titanic* is shown by the midship section (Fig. 14) and the elevation on Plate III. There are eight steel decks amidships—the boat deck, promenade deck (A), bridge deck (B), shelter deck (C), saloon deck (D), upper deck (E), middle deck (F), and lower deck (G)—while at the ends an extra deck—known as the orlop deck—is fitted, making nine decks in all.

The main structure of the vessels ends at the bridge deck, which is carried for 550 feet amidships. To raise the ends of the ships well above the waterline without having recourse to a large sheer, a poop 106 feet long and a forecastle 128 feet long are provided. Above the bridge deck, the deckhouse sides and deck plating are of lighter scantling and have two expansion joints, one forward and one aft, to prevent heavy stresses coming upon the thin plating in a seaway. The main scantlings have been determined by Messrs. Harland and Wolff's long experience with large vessels. Material is massed at the upper flange of the equivalent girder by making the bridge and shelter deck plating and sheer strakes of great thickness and fitting doubling at these points, while the lower flange is strengthened by doubling the bilge plating. The material used throughout is mild steel.

The keel of each vessel is formed by a single thickness of plating 1½in. thick and a flat bar 19½in. wide by 3in. thick. The bottom plating is hydraulic riveted up to the bilge, the strakes being arranged clincher fashion for this purpose; and the frame bottoms are joggled to avoid the use of tapered packing pieces. To reduce the number of butts and overlaps to a minimum, plates of large size are adopted. The shell plates generally are 6 feet wide and about 30 feet long, with a weight of 2½ to 3 tons. The largest shell plates are 36 feet long and weigh 4¼ tons each.

A cellular double bottom extending right out to the ship's sides, with floors on every frame, is fitted throughout each vessel. This double bottom is 5ft. 3in. deep, and is increased to 6ft. 3in. in the reciprocating engine room. The subdivision of the double bottom into separate tanks is arranged to provide ample facilities for trimming the vessel or for correcting any list due to unequal disposition of coal or cargo. The double bottom is divided into four compartments transversely by the watertight centre keelson and watertight longitudinals on each side 30ft. from the centre line, the subdivision being completed in the usual manner by transverse watertight floors. The subdivision into four tanks transversely is also of benefit to the stability of the ship, owing to the limited width of the free water surfaces in the tanks used for the boiler feed water and for the passenger water services. Besides the continuous tank girders mentioned above, there are five intercostal tank girders amidships on each side of the centre keelson, disposed as shown in Fig. 14, and additional girders are fitted beneath the engine rooms.

The spacing of the frames is 3ft. amidships, reduced to 24in. forward and 27in. aft. The frames are of 10-in. channel sections, except at the extreme ends, where a built section of frame and reverse bar is adopted. Web frames 30in. deep are fitted on every third frame (9ft. apart) in the boiler and turbine rooms, and on every second frame (6ft. apart) in the reciprocating engine room. The channel frames extend from the tank top to the bridge deck, some of these bars having a length of about 66ft. and weighing nearly one ton. The beams of the main structure are also

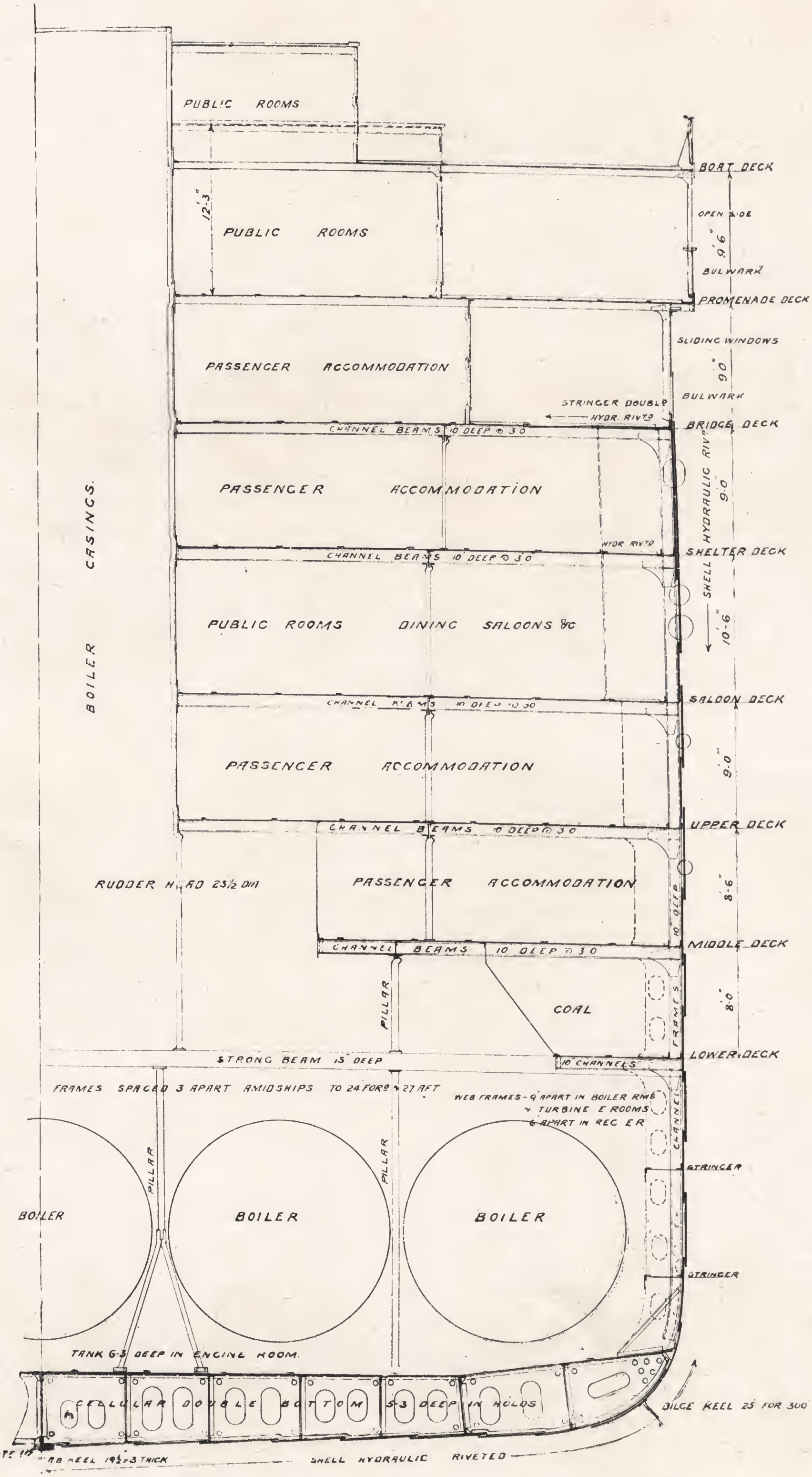


Fig. 14.—Midship Section of "Olympic" and "Titanic."

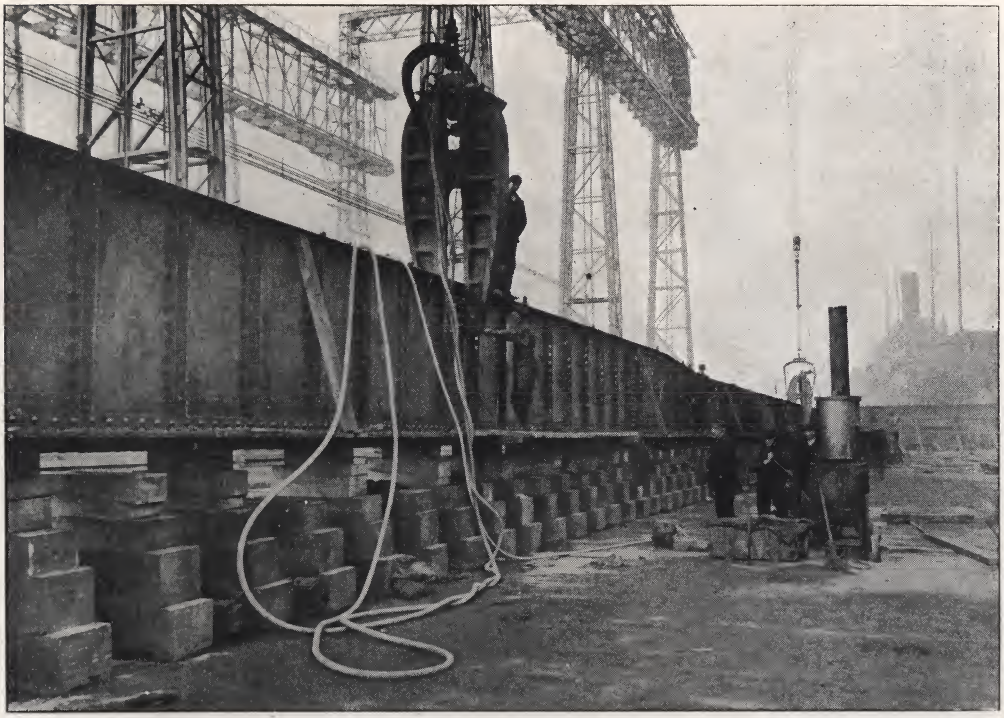


Fig. 15.—Hydraulic Riveter at Work on the Vertical Keel Plate.

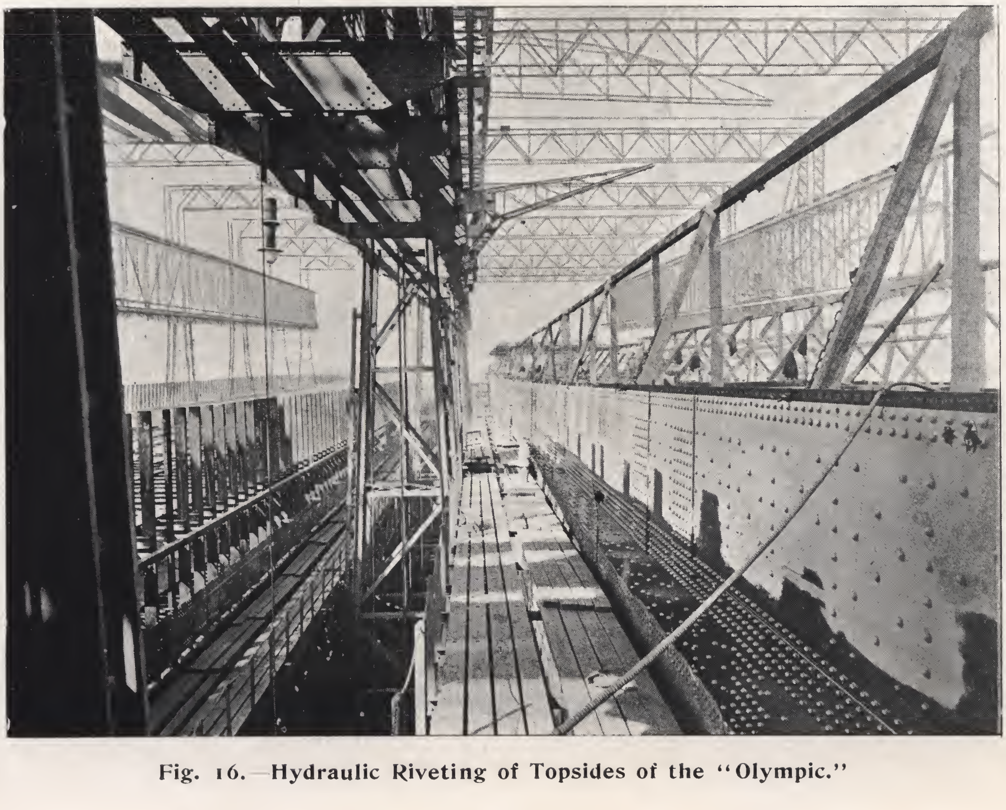


Fig. 16.—Hydraulic Riveting of Topsides of the "Olympic."

of channel section 10in. deep amidships, the largest being 92ft. long and weighing $1\frac{1}{4}$ tons. The beams are connected to the frames by bracket knees. The transverse strength is also maintained by the watertight bulkheads, of which there are fifteen in all, and a number of non-watertight bulkheads forming the cross bunker ends. The decks have a camber of 3 inches.

The beams of the bridge, shelter, saloon, and upper decks amidships are supported by four longitudinal girders, which are in turn carried by narrower at the ends the number of rows of pillars is reduced.

Bilge keels 25in. deep, as shown on the section in Fig. 14, are fitted for about 300ft. of the vessel's length amidships, to minimise rolling in a seaway.

The two decks forming the superstructure of each ship and the navigating bridge are built to ensure a high degree of rigidity. At the sides they are supported on built-up frames in line with the hull frames, but at wider intervals. The deckhouses are specially stiffened by channel section

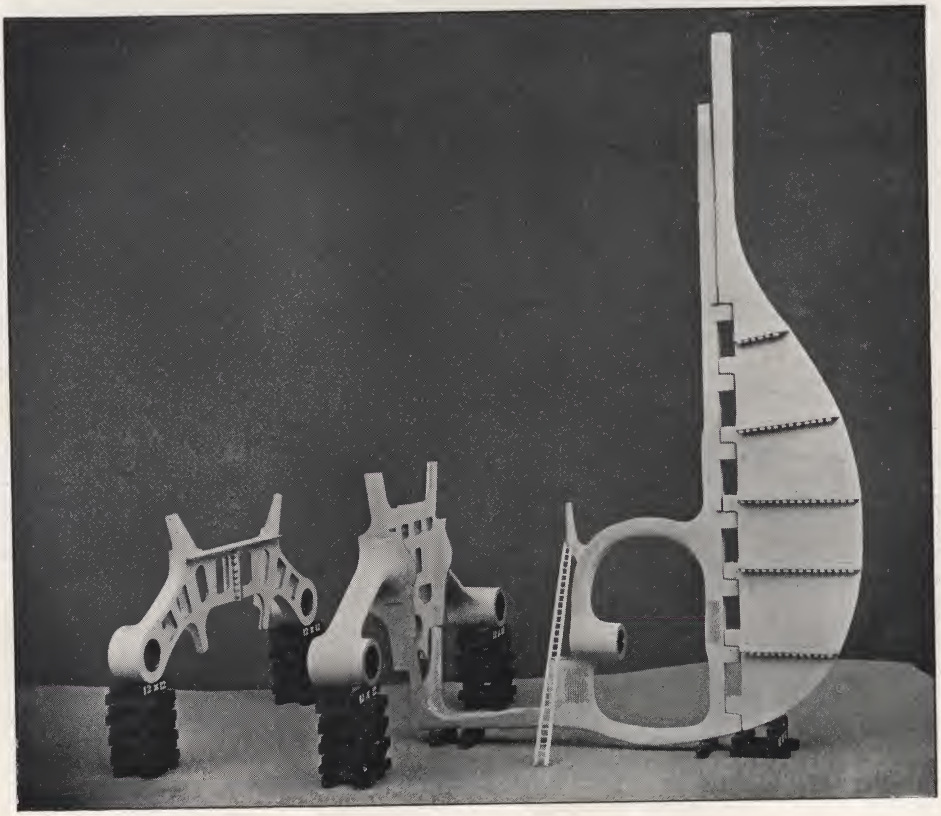


Fig. 17.—Arrangement of Stern Castings.

solid round pillars spaced 9ft. apart. Below the middle deck in the boiler rooms round pillars are also adopted, 9ft. apart, in conjunction with strong beams carried across at the lower deck level in way of each web frame. In the case of the inner rows the pillars are spaced out so that they do not interfere with the working passage. In the engine rooms and holds the pillars below the middle deck are wide spaced and of circular built section, the deck girders being increased in strength to suit the longer span. As the ship gets steel fitted in the frame work; and where, as on the boat deck, the public rooms pierce the deck, heavy brackets are introduced to increase the resistance to racking forces when the ship is steaming through a heavy seaway. The boat and promenade decks are increased to 94ft. wide, to enlarge the promenade space. All exposed decks are sheathed with wood, but inside deckhousse and on all decks not exposed to the weather Harding's Litosilo is adopted as the deck covering. This Litosilo was supplied by Messrs. C. S.

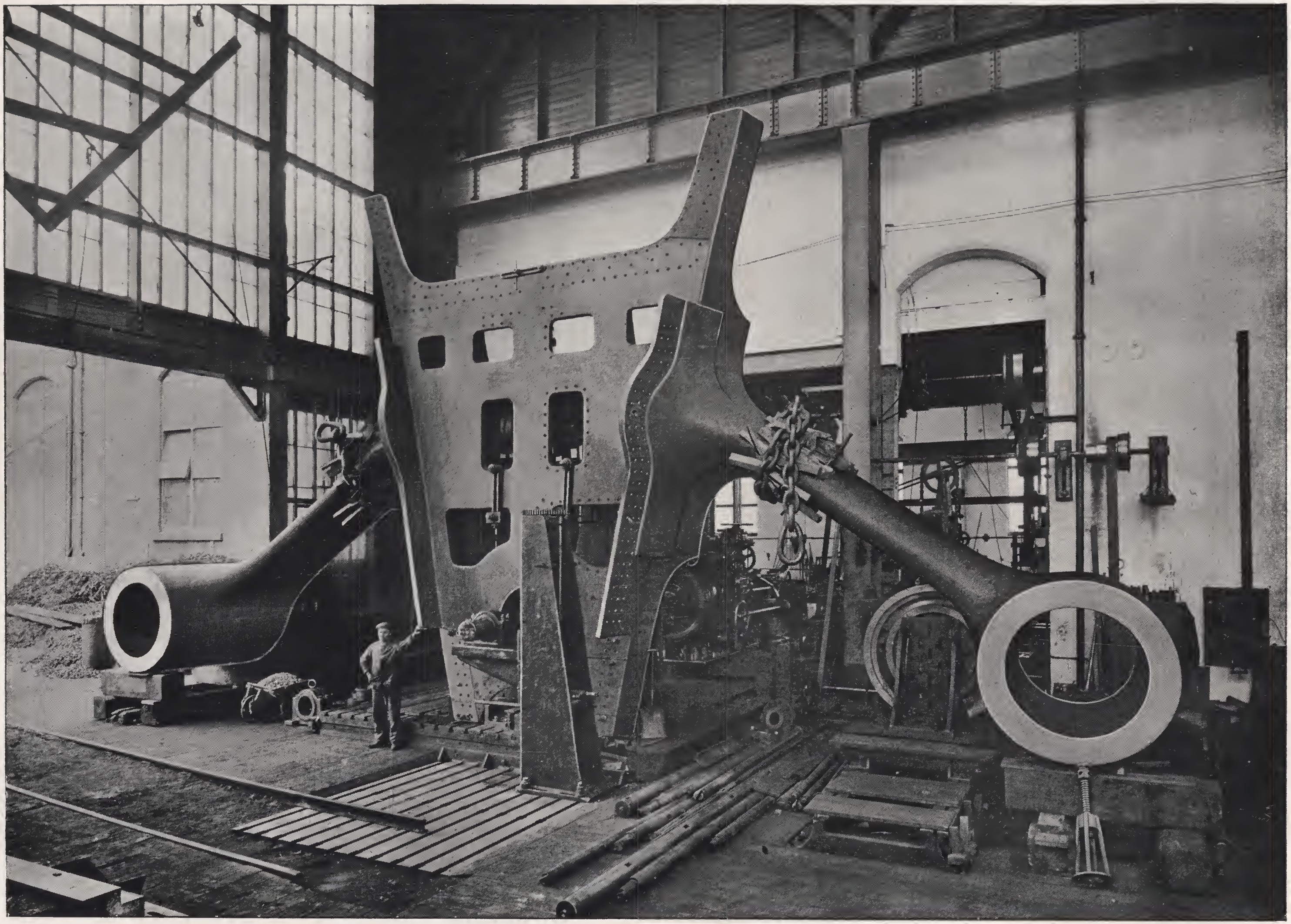


Fig. 18.—After Propeller Brackets.

Wilson & Co., of Liverpool, some 40,000 square yards being required for each vessel.

Riveting.

Some idea of the great importance of the riveting in the *Olympic* and *Titanic* will be gathered from the fact that there are half a million rivets in the double bottom of each vessel, weighing about 270 tons, the largest rivets being $1\frac{1}{4}$in. diameter; while in each ship when completed there will be something like three million rivets, weighing about 1,200 tons. To ensure the best workmanship, hydraulic riveting has been adopted whenever possible. Nearly the whole of the double bottom, including the bottom shell plating up to the turn of the bilge and the topside shell and stringer plates and doublings, have been riveted by hydraulic power. A hydraulic riveter at work on the vertical keel plate of the *Olympic* is shown in Fig. 15, the adjacent portable furnace being used for heating the rivets. Similar riveters can also be observed at work in a number of the illustrations showing the various stages in the building of the ship, and the great extent and strong appearance of the topside hydraulic riveting are very clearly shown in Fig. 16.

The seams of the bottom plating are double riveted, and of the topside plating treble and quadruple riveted. The butts of the bottom plating are overlapped and quadruple riveted, as are also the butts of the side plating, except in the way of the topside shell and doublings, where double straps are adopted.

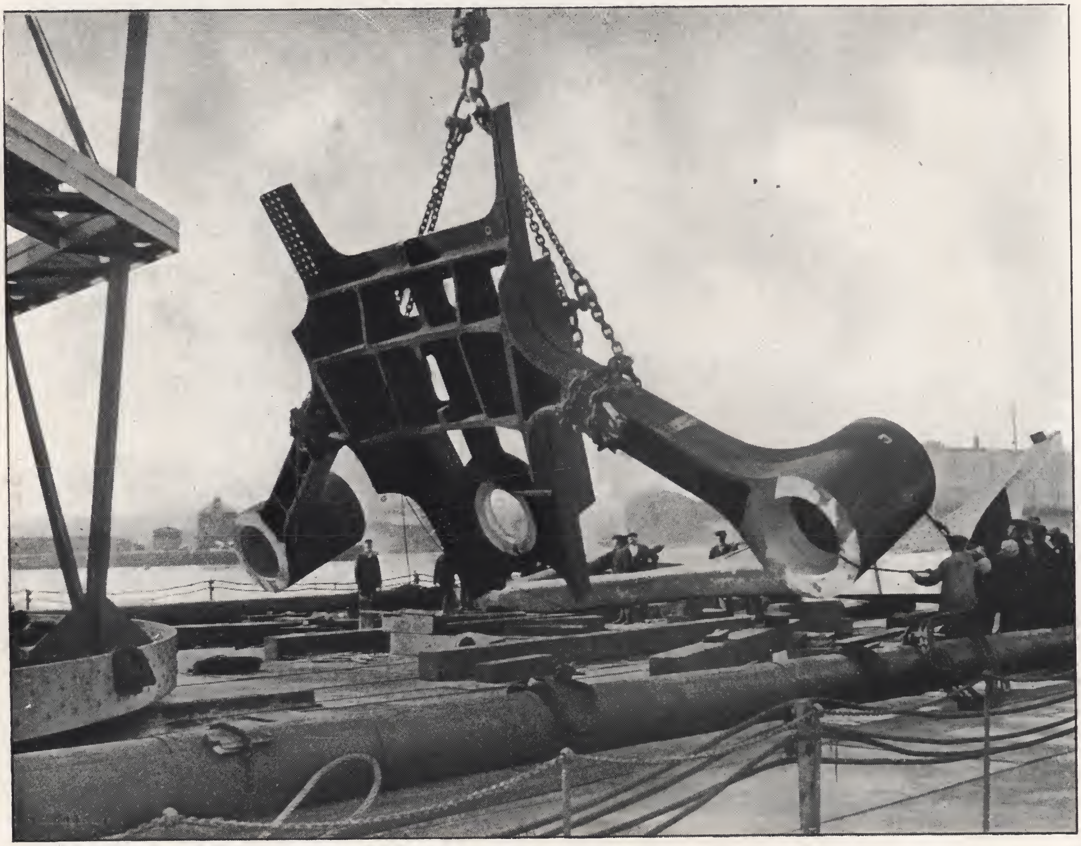


Fig. 19.—After Propeller Brackets being Weighed.

Stem and Stern Castings.

The general arrangement of the stern castings of the *Olympic* and *Titanic* will be seen from Fig. 17. As each vessel has triple screws, the stern frame is provided with a boss and aperture for the centre or turbine propeller; while the wing or reciprocating propeller shafts are carried by boss arm castings, round which the shell plating is carried to form "bossing" of Messrs. Harland and Wolff's improved type. All these castings have been supplied by the Darlington Forge Company, and

are of Siemens-Martin mild cast steel, with the exception of the rudder stock which is of forged ingot steel. Some idea of the immense size of the stern castings will be obtained from the particulars of their weights given in following table :—

TABLE III.—WEIGHTS OF CASTINGS.

Stern frame (two pieces)...............	70	tons.
After brackets (two pieces)	$73\frac{3}{4}$	,,
Forward brackets (two pieces)......	45	,,
Rudder (six pieces)	$101\frac{1}{4}$	,,
Stem bars	$7\frac{1}{4}$	,,
Stem connection piece to keel	$3\frac{1}{2}$	,,

The stern frame is of dished section, 18in. by 11in., increased to 21in. by 11in. solid in way of the aperture, and is in two pieces connected by specially designed scarphs, as shown in Fig. 17. The total height is 68ft. 3in. and length 37ft. 4in. A large palm is provided at the forward end to form a strong connection to the after boss arms and the main structure of the vessel. The scarphs are connected with best Lowmoor iron rivets 2in. dia., there being 59 rivets in the forward and 53 rivets in the after scarph, with a total weight exceeding one ton. The great care exercised in fitting these to ensure a strong connection is suggested by the fact that they were all turned and fitted and specially closed with rams.

The after boss arms are in two pieces, connected at the centre line of the vessel by strong

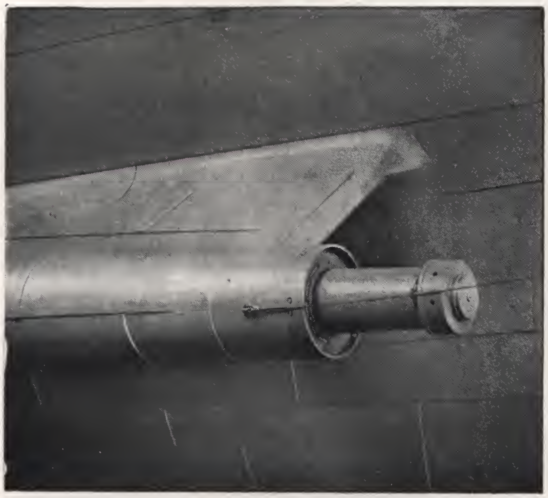


Photo by] [Frank & Sons, So. Shields.

Fig. 20.—Shell Plating in Way of "Bossing."

deep flanges to form a continuous web right across the ship. This web, again, is riveted to a 2-in. steel plate of special quality, extending from side to side of the vessel. The immense size of these castings is well illustrated by Figs. 18 and 19, which also show the holes for the rivets by means of which they are securely attached to the stern frame, shell plating, floors, and framing of the ship. The centres of the wing shafts are 39ft. at the after brackets, and the bosses are 4ft. 10in. diameter. The manner in which the shell plating is carried round the bossing is well shown in Fig. 20. The introduction of the forward brackets as a means of increasing the strength of the ship at this part is noteworthy. In this case also the two arms have been made in separate pieces and connected by bolts at the centre line of the ship, as will be seen from Fig. 17, the whole being securely attached to the ship's plating and framing.

The rudder (see Fig. 17) is of solid cast steel, built in five sections and coupled together with bolts varying from $3\frac{1}{2}$in. to 2in. diameter. The rudder stock is of forged steel $23\frac{1}{2}$in. diameter, and was made from a special ingot of the same quality as used for gun jackets. On the completion of the forging an inspection hole was bored through the stock of the rudder in order to ensure that there were no flaws. The length overall of the rudder is 78ft. 8in., and width 15ft. 3in. The pintles are 11in. diameter, of hard steel, and are arranged each to take their own proportion of the rudder weight, bearing upon hard steel discs inside the stern post gudgeons. A special feature is that the bottom of the rudder is so arranged that screw jacks can be employed for lifting it in dry dock.

The stem bar is of the usual rolled section, and is connected by a steel casting to the centre keelson and keel of the ship. A special feature is the cast-steel hawsepipe attached to the upper portion of the stem bar, to take the steel wire hawser provided for use with the central bower anchor. The weight of this casting is $6\frac{1}{4}$ cwt.

Watertight Subdivision.

THE watertight subdivision of the *Olympic* and *Titanic* is very complete, and is so arranged that any two main compartments may be flooded without in any way involving the safety of the ship. There are fifteen transverse watertight bulkheads extending from the double bottom to the upper deck at the forward end of the ship, and to the saloon deck at the after end—in both instances far above the waterline. The room in which the reciprocating engines are placed is the largest of the compartments, being 69ft. long, while the turbine room is 54ft. long. The boiler rooms are generally 57ft. long, with the exception of that nearest the reciprocating engine compartment. The holds are 50ft. long.

The watertight doors giving communication between the various boiler rooms and engine rooms are arranged, as is usual in White Star vessels, on the drop system. They are of Messrs.

Harland and Wolff's special design, of massive construction, as will be seen from Fig. 21, and are protected with oil cataracts governing the closing speed. Each door is held in the open position by a suitable friction clutch, which can be instantly released by means of a powerful electro-magnet controlled from the captain's bridge, so that in the event of accident, or at any time when it may be considered advisable, the captain can, by simply moving an electric switch, instantly close the doors throughout and make the vessel practically unsinkable. Each door can also be closed from below by operating a lever fitted in connection with the friction clutch. As a further precaution floats are provided beneath the floor level, which, in the event of water accidentally entering any of the compartments, automatically lift and thereby close the doors opening into that compartment if they have not already been dropped by those in charge of the vessel.

A ladder or escape is provided in each boiler room, engine room, and similar watertight compartment in order that the closing of the doors at any time shall not imprison the men working inside, but the risk of this happening is lessened by electric bells placed in the vicinity of each door, which ring prior to their closing and thus give warning to those below.

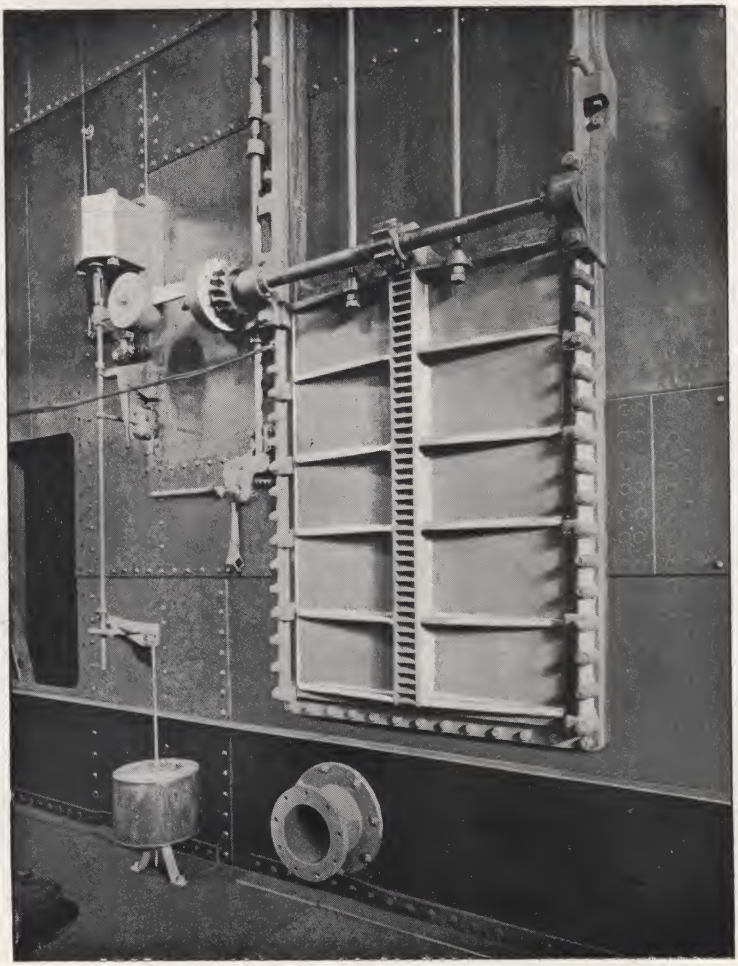


Fig. 21.—Double Cylinder Watertight Door.

Building Stages of the "Olympic."

A COMMENCEMENT was made with the laying of the keel of the *Olympic* on the 16th December, 1908. The progress made by the 1st January, 1909, is shown in Fig. 22. The next photograph (Fig. 23), taken on the 18th February, 1909, shows the flat keel and

Fig. 22.—The "Olympic's" Keel, laid 1st January, 1909.

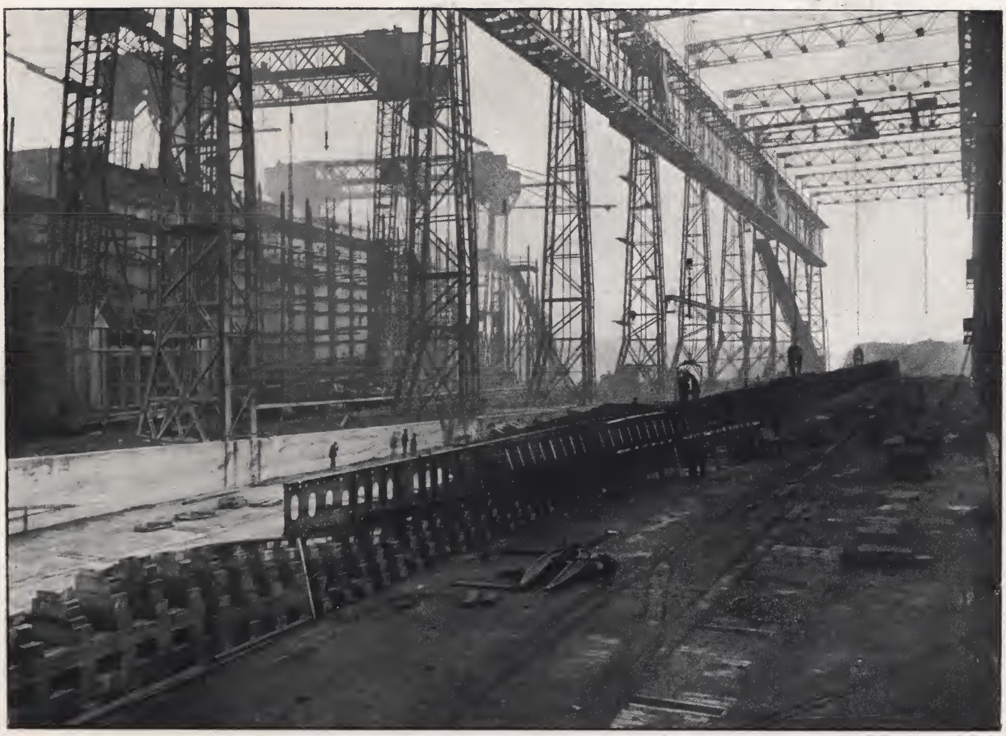


Fig. 23.—Vertical Keel Plate and Floors, looking Forward. (18th February, 1909.)

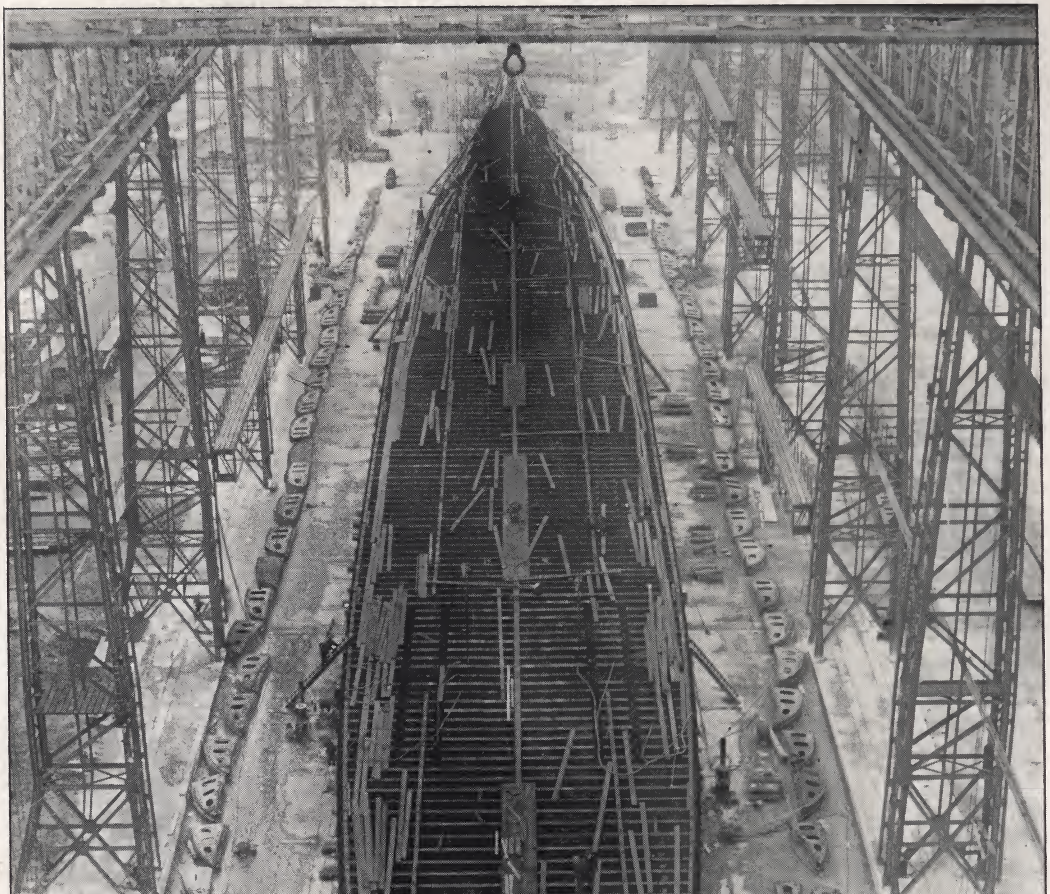


Fig. 24.—Bird's Eye View of the "Olympic" from Top of Gantry. (15th April, 1909.)

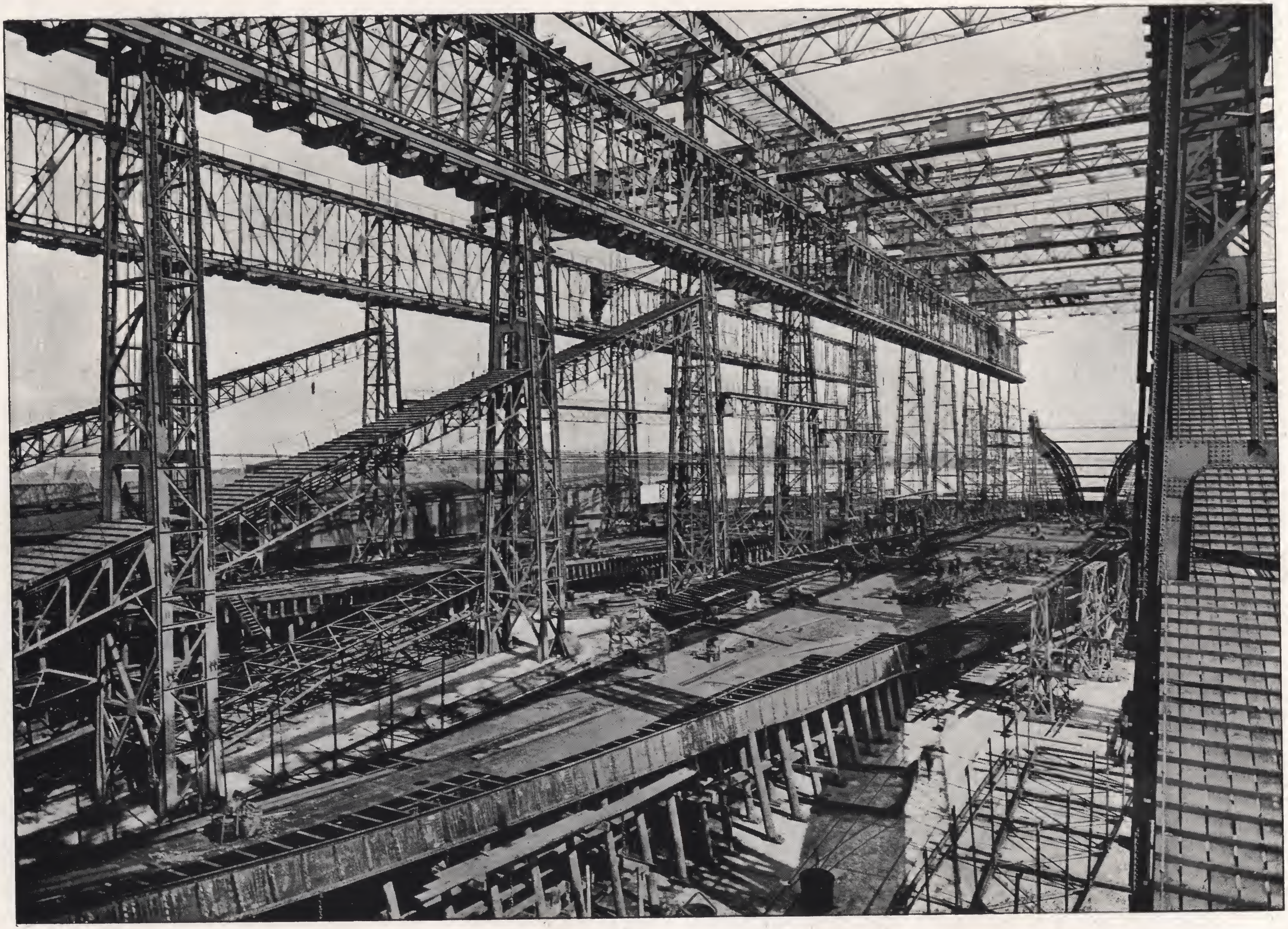


Fig. 25.—Tank Top and After End Framing of the "Olympic." (30th July, 1909.)

vertical keel plate completed and a commencement made with the erection of the floors. Fig. 24 is a striking photograph taken from the top of the gantry on the 15th April, 1909, and shows the erection and riveting of the double bottom floors well advanced, with the exception of the wing tank floors which will be seen lying on the ground alongside. The next illustration (Fig. 25), taken on the 30th July, shows the tank top partly plated and a commencement made with the after end framing, of which a nearer view is shown in Fig. 26, taken on the same date. The vessel was almost framed when the next photograph (Fig. 27) was taken on the 18th November, 1909, the last frame being raised into position on the 20th of that month (Fig. 28).

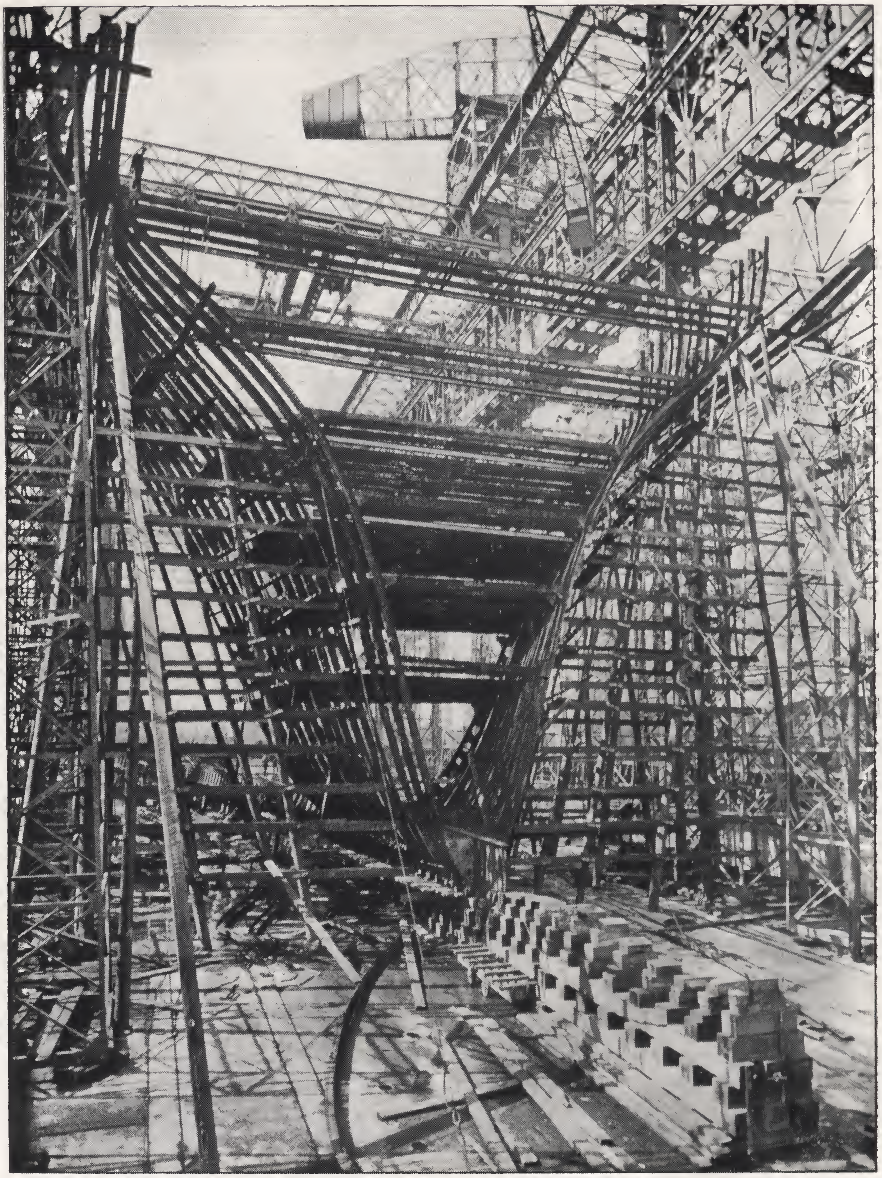


Fig. 26.—After End Framing of the "Olympic." (30th July, 1909.)

Work was all the time proceeding apace in the interior of the vessel in connection with the

beams and plating of the various decks. The view of the shelter deck looking aft, reproduced in Fig. 29, gives a very good impression of the vessel's size and shows clearly the deck beams and plating. The shell plating of the *Olympic* was completed and almost entirely riveted by the beginning of April, 1910, as will be seen from the next photograph (Fig. 30), taken on the 7th of that month. It will be noticed that the sister ship *Titanic*, on the adjoining berth, was by this time fully framed. Other work besides the steel work now began to make rapid headway. Fig. 31 shows a photograph of the first-class dining saloon taken on the 6th June, 1910. It will be seen that a commencement had then been made with the grounds for the joinerwork. This photograph also shows the novel arrangement of sidelights in double rows adopted for lighting the saloon.

The support of the vessel during construction by means of shores under the bottom is shown in Fig. 32, which also gives an interesting view of the bottom riveting. The final illustrations of the vessel on the stocks show a view of the forecastle deck (Fig. 33) and a bow and stern view taken shortly before the launch (Figs. 34 and 35).

Launch of the "Olympic."

THE *Olympic* was successfully launched on the 20th October, 1910, in the presence of the Lord Lieutenant of Ireland, the Countess of Aberdeen, and a number of distinguished guests, the final arrangements being personally directed by Lord Pirrie. The launching operation has already been fully dealt with in *The Shipbuilder*,* and from our previous article we reproduce Figs. 36 and 37 showing the forward launching cradle and brackets, Fig. 38 representing one of the two hydraulic triggers by which alone the vessel was held when all the shores and blocks were removed, and Fig. 39 showing the pump and pressure gauge associated with the launching triggers. A striking photograph of the vessel immediately after leaving the ways is reproduced in Fig. 40. The leading particulars of the launch as given in our former article are repeated for the convenience of our readers in Table IV.

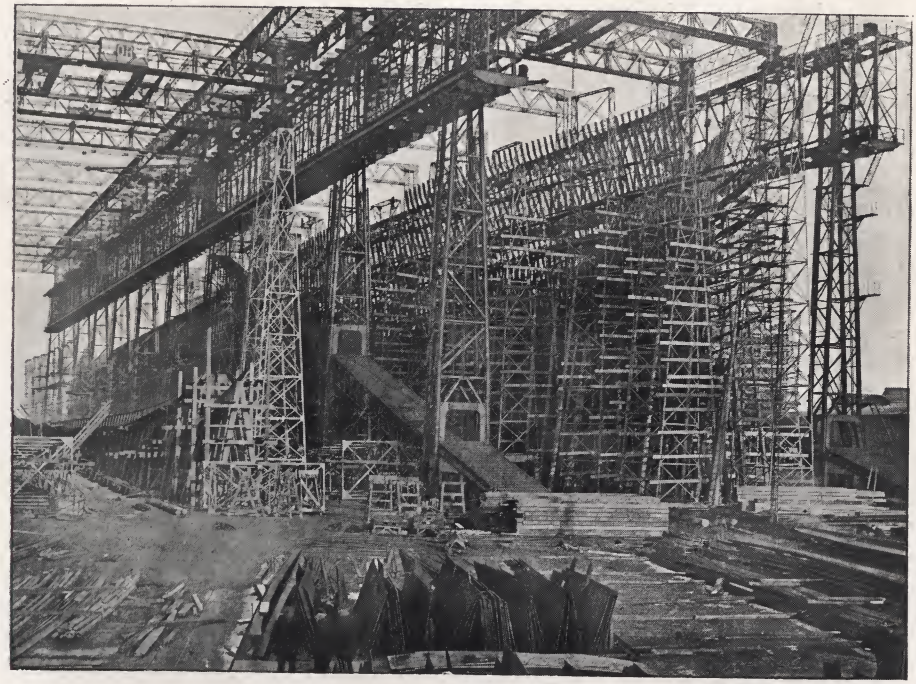


Fig. 27.—The "Olympic" almost Framed. (18th November, 1909.)

TABLE IV.—LAUNCHING PARTICULARS.

Draught forward, 15ft. 8in.; aft, 20ft.; mean, 18ft. $0\frac{1}{2}$in.
Launch weight excluding cradle .... 24,600 tons.

* No. 19, Vol. V.

Length of standing ways .... about 850 feet.
Length of sliding ways .... about 750 feet.
Standing ways, of oak .... 6ft. 9in. wide.
Sliding ways, of pitch pine .... 6ft. 3in. wide.
Pressure per sq. ft. of bearing surface .... 2·6 tons.
Declivity of ways, $\frac{3}{8}$in. per foot for forward half length, increasing to $\frac{1}{2}$in. per foot for the remainder.

Completion of the "Olympic."

After the launch, the *Olympic* was moored at the new deep-water wharf belonging to the Belfast Harbour Authorities, and a commencement was made with the work of fitting the propelling machinery on board. The 200-ton floating crane belonging to the builders was employed for the purpose, and may be seen putting a boiler on board in Fig. 41. This crane, which is one of the largest floating cranes in existence, can lift a weight of 150 tons to a height of 149ft. at a radius of 100ft. with a list of only 4 degrees; while the small hook can lift 50 tons

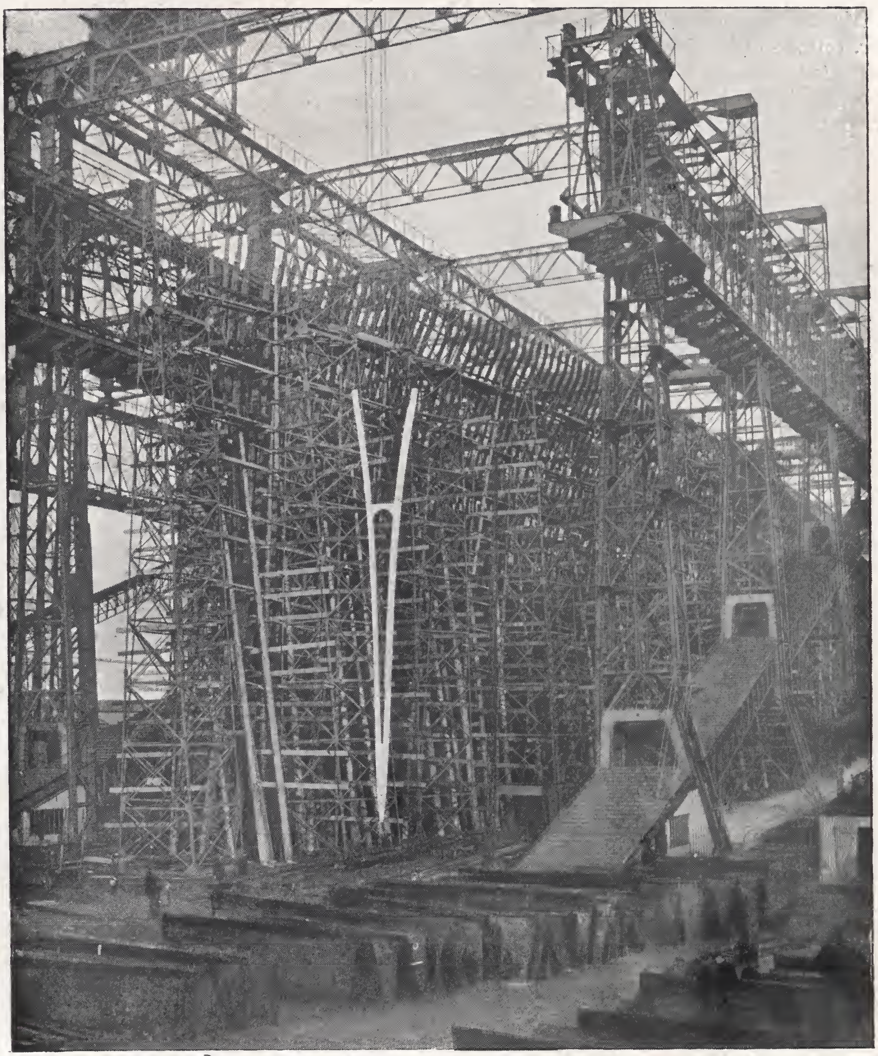


Fig. 28.—Last Frame of the "Olympic" being Raised. (20th November, 1909.)

Quantity of lubricants used:—
Tallow .... 15 tons.
Tallow and train oil, mixed .... 5 tons.
Soft soap .... 3 tons.
Time from start till vessel left ways......... 62 seconds.
Maximum velocity .... $12\frac{1}{2}$ knots per hour.
Drags, 3 anchors each side and 80 tons cable, all disposed in the bed of the river.

Fig. 29.—View of the "Olympic's" Shelter Deck, looking Aft. (31st March, 1910.)

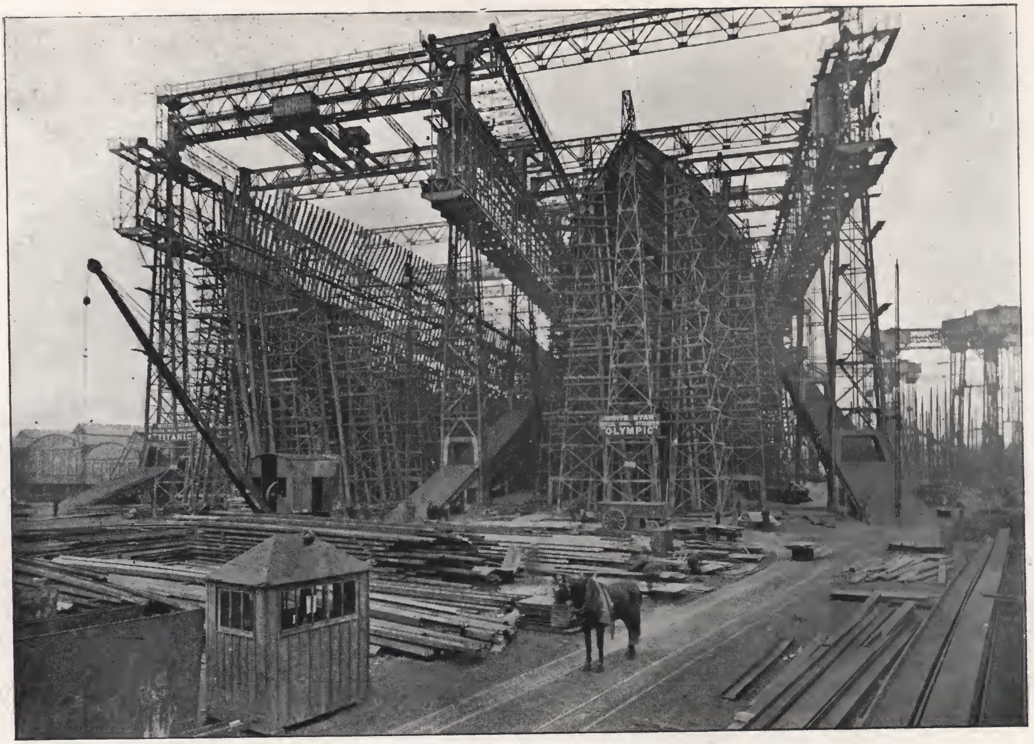


Fig. 30.—The "Olympic" Plated and the "Titanic" Framed. (7th April, 1910.)

Fig. 31.—Progress of Work in the "Olympic's" First-class Dining Saloon. (6th June, 1910.

Fig. 32.—Shoring under the "Olympic's" Bottom.

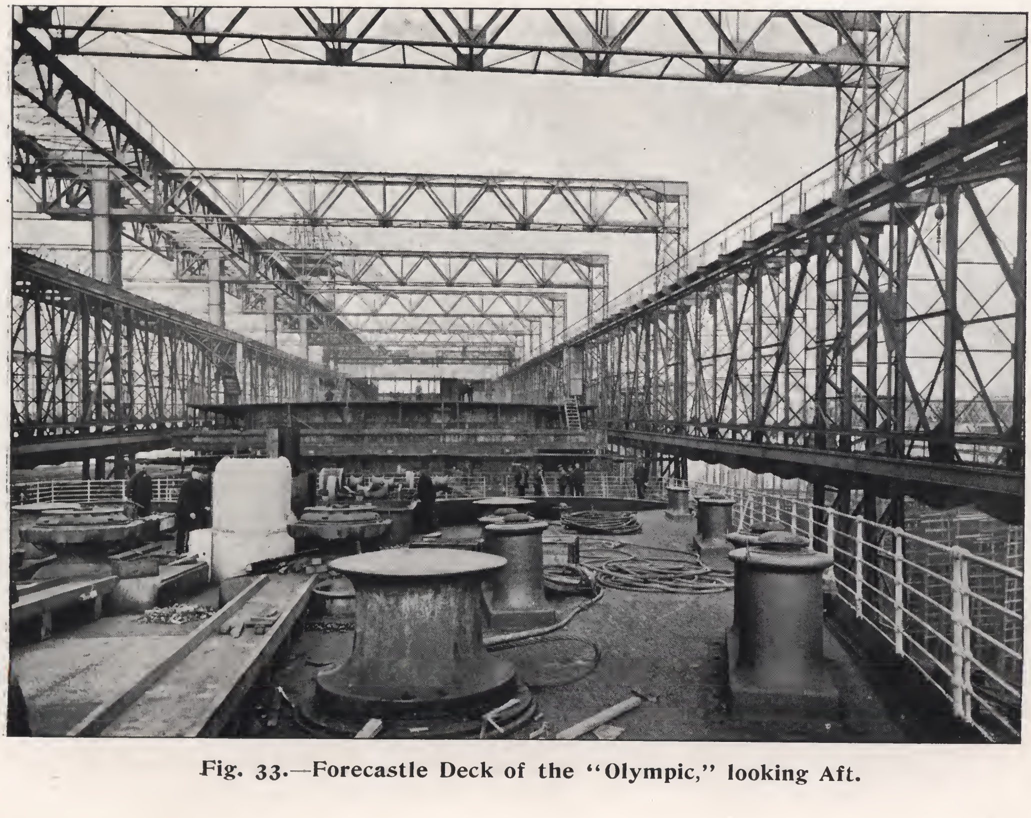


Fig. 33.—Forecastle Deck of the "Olympic," looking Aft.

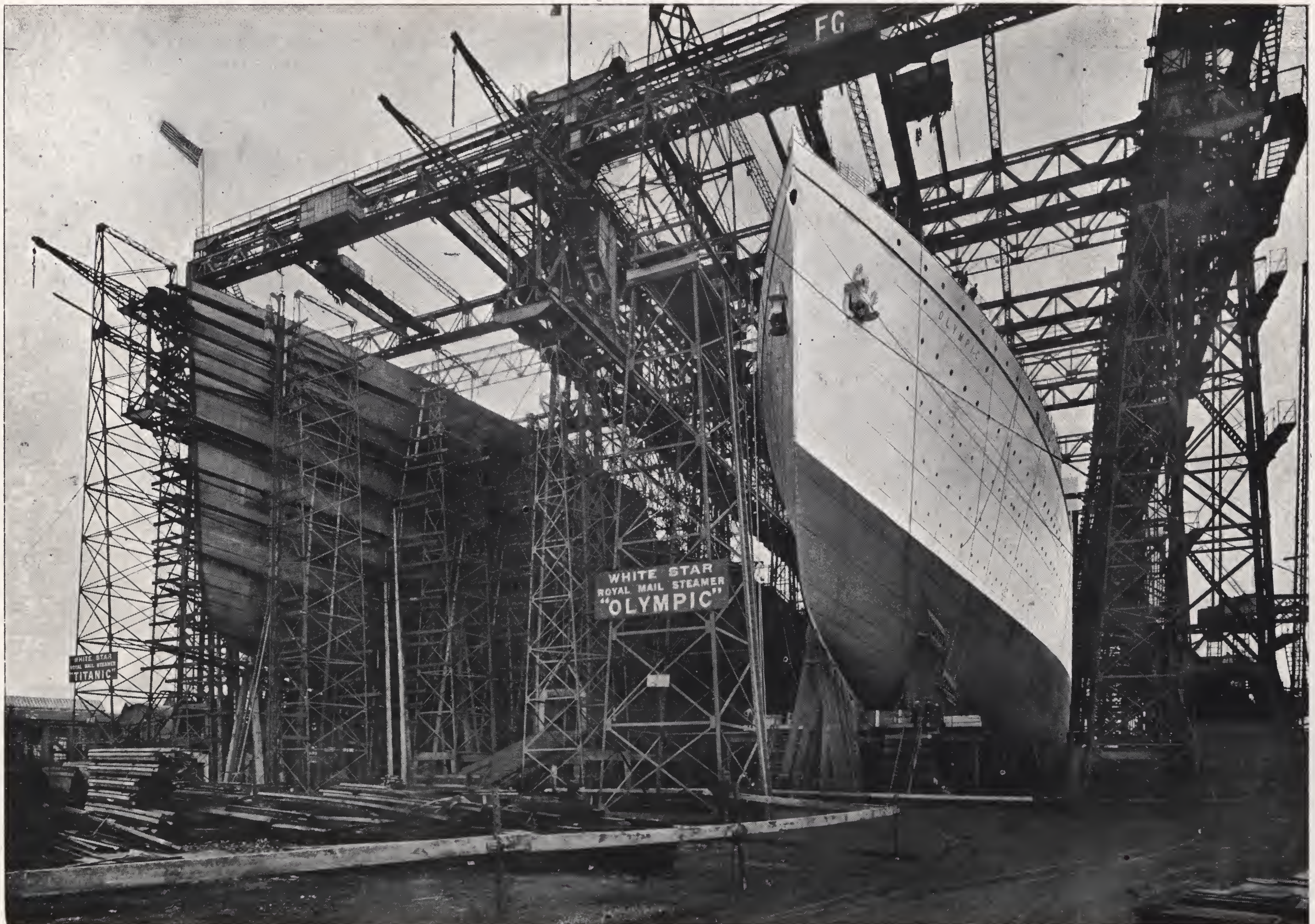


Photo by] [Frank & Sons, So. Shields.

Fig. 34.—The "Titanic" and "Olympic" on the Stocks, (Photographed on the day the "Olympic" was Launched.)

Photo by] [*Frank & Sons, So. Shields.*

Fig. 35.—The Stern of the "Olympic," immediately before Launching.

Fig. 36.—Forward Launching Cradle.

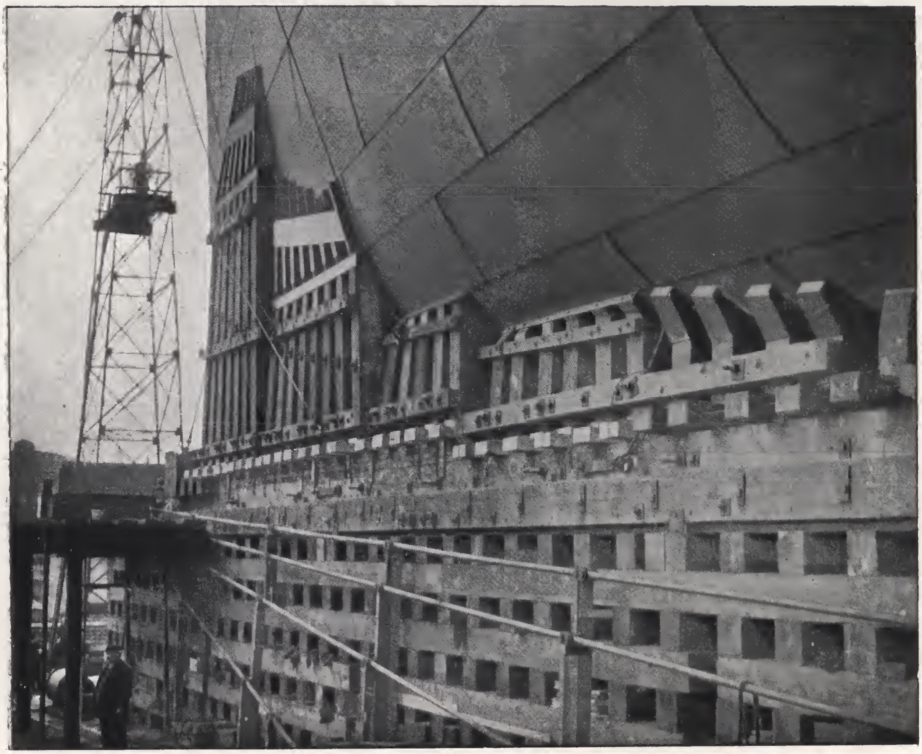


Photo by] [*Frank & Sons, So. Shields.*

Fig. 37.—Forward Cradle and Make-up of Ways.

Fig. 38.—One of the Hydraulic Launching Triggers.

Photo by] [*Frank & Sons, So. Shields.*

Fig. 39.—Pump and Pressure Gauge associated with Launching Trigger.

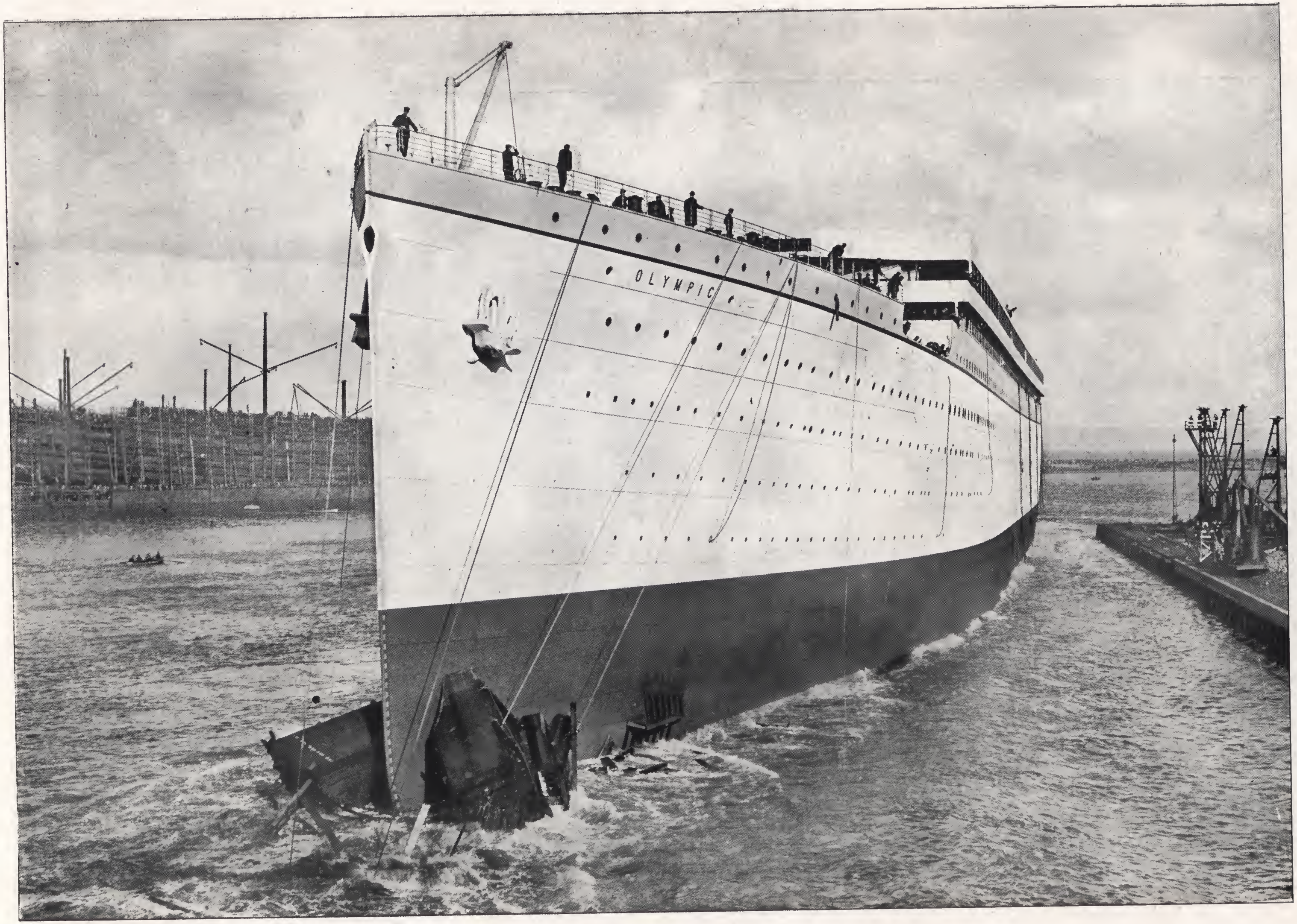


Photo by] **Fig. 40.—The Launch of the "Olympic."** (20th October, 1910.) [*Frank & Sons, So. Shields.*

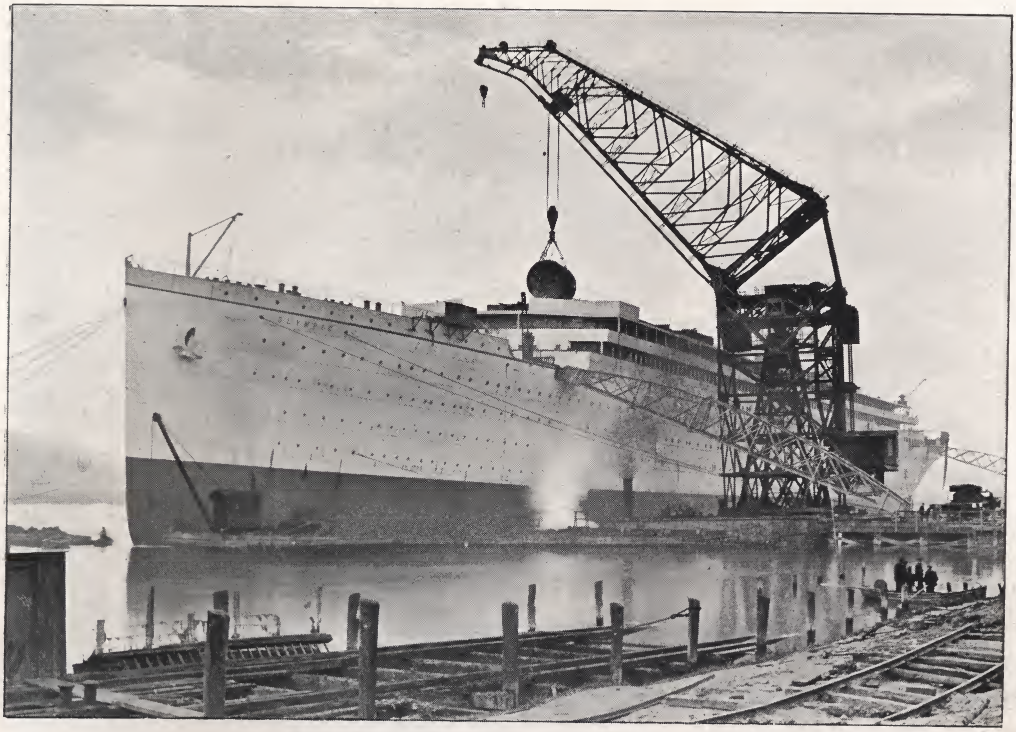


Fig. 41.—Floating Crane lifting a Boiler on board the "Olympic." (9th November, 1910.)

Fig. 42.—The "Olympic" in Graving Dock. (1st April, 1911.)

Fig. 43.—"Olympic" almost completed.

at a radius of 140ft. Fig. 41 also shows the strong steel lattice girder gangway which was used for communication from the wharf to the ship, as well as one of the rafts which were provided at the forward and after ends to keep the vessel the required distance from the quay. Fig. 43 shows the ship in a more advanced stage, the four funnels and two masts having by this time been erected.

The *Olympic* was docked on the 1st April, 1911, in the new graving dock belonging to the Belfast Harbour Commissioners, of which the principal dimensions are given in Table V., and which has the distinction of being the largest graving dock in the world at the present time. The responsible task of docking and undocking was accomplished without a hitch. An illustration of the vessel in dock is shown in Fig. 42.

TABLE V.—THE NEW BELFAST DOCK.

Nominal length of dock on floor	850′	0″
Length if caisson be placed against outer face quoins	886′	7½″
Width of dock on floor	100′	0″
Width at entrance to dock...............	96′	0″
Width at coping level	128′	0″
Width at lowest altar course..	104′	6″
Depth of dock floor at centre below level of high water of ordinary spring tides	37′	3″
Top of keel blocks below level of high water of ordinary spring tides	32′	9″
Height of top of blocks above floor ...	4′	6″
Level of entrance sill above dock floor at centre of dock..................	2′	0″
Bottom of dock floor at sides of dock below coping level.......................	43′	6″

The *Olympic* was completed by the end of May, 1911, the work of fitting out having been finished in just over seven months from the date of launching, a remarkable performance, especially when it is considered that Messrs. Harland and Wolff were also completing afloat during the same period the two White Star tenders *Nomadic* and *Traffic* for use at Cherbourg, the P. & O. liner *Maloja* (the largest ship of that fleet), the Aberdeen liner *Demosthenes*, and the Union-Castle intermediate liner *Galway Castle*, as well as preparing for the launch of the *Titanic*. Between 3,000 and 4,000 men were engaged on the completion of the *Olympic*, on board and in the shops, the total number of men employed by the builders at this period being about 14,000. A reference to the trial trip of the vessel and her departure from Belfast will be found near the end of the present issue.

Building Stages of the "Titanic."

THE progress of work in connection with the *Titanic* is illustrated by the photographs we have used for that purpose in the case of the *Olympic*, the vessels having, as already stated, been built on adjoining berths. It is interesting to note, however, the dates upon which definite stages in the construction of the second vessel were reached. The keel was laid on the 31st March, 1909, or about three months after the *Olympic* was commenced. By the 15th May following the *Titanic* was framed to the height of the double bottom, and was fully framed on the 6th April, 1910, just a year after laying the keel. The vessel was plated by the 19th October, 1910, and was successfully launched on the 31st May, 1911, the launching arrangements being similar to those adopted for the *Olympic*. It is expected the *Titanic* will be completed and enter upon service early in 1912.

The Propelling Machinery.

THE combination of reciprocating engines with a Parsons low-pressure turbine, which has been adopted for the propelling machinery of the *Olympic* and *Titanic*, is one of the latest examples of progress in marine engineering. The superior economy of the system is due to the fact that increased power is obtained with the same steam consumption by expanding the steam in the low-pressure turbine beyond the limits possible with the reciprocating engine. Messrs. Harland & Wolff were among the first to see the advantages of the combination arrangement and to put the system to the test of actual experience. This was done in the case of the *Laurentic*, already referred to, and the successful results obtained with this vessel led to the introduction of engines of the combination type in the new White Star liners and other vessels built and building at Belfast.

Arrangement of Machinery.

As will be seen from the general arrangement plans of the ships (Plates III. and V.) and the elevations and plans of the boiler and engine rooms (Plates VI., VII., and VIII.), in the *Olympic* and *Titanic* nearly the whole of the space beneath the upper deck E is occupied by the steam-generating plant, coal bunkers, and propelling machinery. The boiler installation and bunkers occupy six watertight compartments, having a total length of 320 feet. The engine rooms take up a further length of 123 feet, and the electric engine room and shaft tunnels occupy the remaining portion of the ship below the orlop deck. Of the four funnels provided, the foremost three are required for the boiler rooms, while the fourth is used for ventilating purposes and has also built into it the chimney from the extensive galleys.

As is well known, the *Olympic* and *Titanic* are triple-screw steamers, each wing propeller being driven by one set of reciprocating engines, and the central propeller by the low-pressure turbine. Owing to the great size of the units, it was found necessary to place the latter in a separate compartment abaft the reciprocating engine room and divided from it by a watertight bulkhead. The reciprocating engine room is placed immediately abaft the aftermost boiler room, and contains, in addition to the main engines, a large amount of auxiliary machinery. In the wings are placed the main feed and hotwell, bilge, sanitary, ballast, and fresh water pumps, the auxiliary condenser, the surface heater, and the contact heater, which latter is placed high up in the casing at the centre line ; while on the port side space has been found for the extensive refrigerating plant, and on the starboard side for a large engineers' workshop, situated on a flat some distance above the floor level and well equipped with machine tools.

The after engine room contains, in addition to the low-pressure turbine, the main condensers with their circulating pumps, twin air pumps, etc., the evaporators and distilling plant, the forced lubrication pumps with two oil coolers, and a pump for circulating water through them, besides several pumps for bilge and other purposes.

Boilers.

ALTOGETHER there are twenty-four double-ended and five single-ended boilers in each vessel, designed for a working pressure of 215 lb., which it is anticipated will be maintained under natural draught conditions. The aftermost, or No. 1 boiler room contains the five single-ended boilers, boiler rooms 2, 3, 4 and 5 contain five double-ended, and the foremost, or No. 6 boiler room contains four double-ended boilers. Owing to the great width of the ships, it was found possible to arrange five boilers abreast, as shown in Fig. 44, except in No. 6 boiler room, where, owing to increased fineness, only four abreast could be fitted.

Each of the double-ended boilers is 15ft. 9in. diameter and 20ft. long, and contains six furnaces ; while the single-ended boilers, which are of the same diameter as the double-ended but are 11ft. 9in. long, contain three furnaces, so that the total number of furnaces is 159. The latter are all of the Morison type, 3ft. 9in. inside diameter, and are provided with fronts of the Downie " boltless " pattern. The firebars are of the Campbell type, supplied by Messrs. Railton, Campbell & Crawford, of Liverpool. The shells of the single-ended boilers are formed in one strake, the double-ended boilers having, as usual, three strakes. All the shell plates are of mild steel $1\frac{1}{16}$in. thick. A view of the boilers arranged in Messrs. Harland & Wolff's works is given in Fig. 45.

The arrangement of uptakes, by which the smoke and waste gases are conveyed to the funnels, is necessarily of a very elaborate nature,

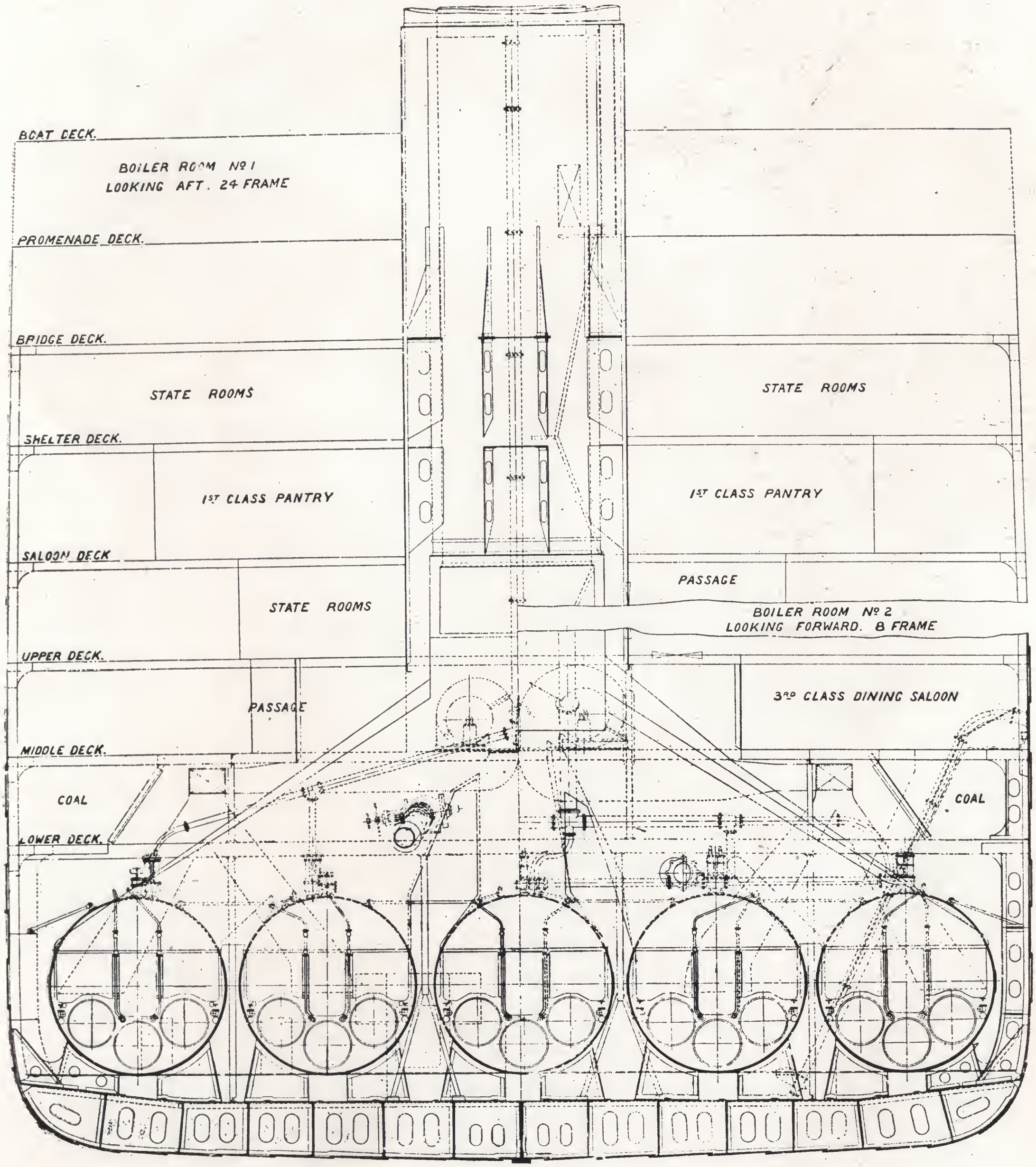


Fig. 44.—Sections through Boiler Rooms Nos. 1 and 2.

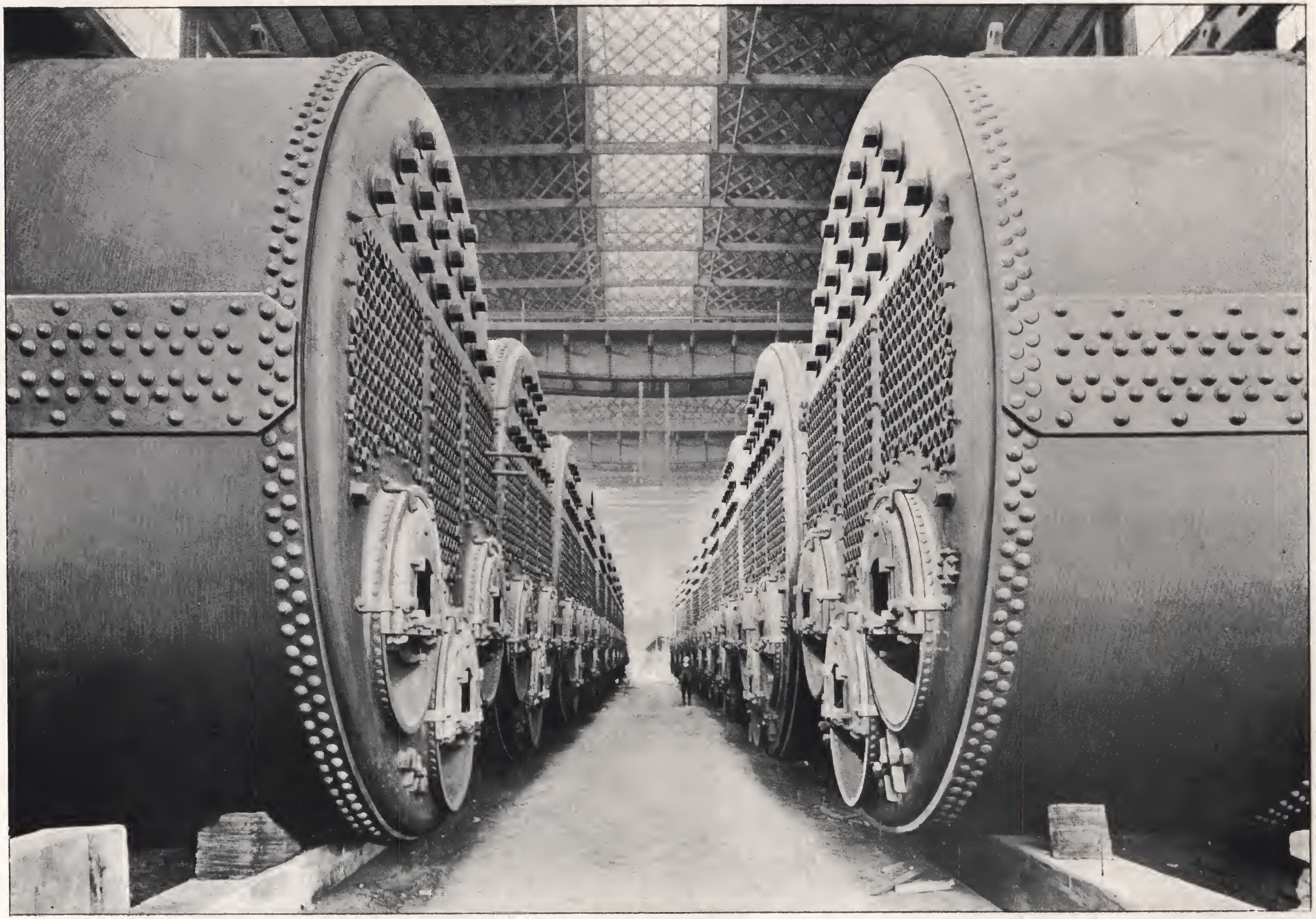


Fig. 45.—Boilers arranged in Messrs. Harland & Wolff's Works.

no less than twenty branches being required to one funnel in the case of boiler rooms 3 and 4. The branches from adjoining boiler rooms are united immediately above the watertight bulkhead separating the rooms, the bulkhead thus forming a valuable support to the uptakes and funnel above. One set of uptakes is shown in Fig. 46 and well illustrates their numerous ramifications. The four funnels have an elliptical cross section and measure 24ft. 6in. by 19ft. 0in. Their average height above the level of the furnace bars is 150ft. A striking photograph of the last funnel of the *Olympic* leaving the shops is reproduced in Fig. 47.

an arrangement which reduces the amount of handling of the fuel for each boiler to a minimum. A further advantage of the bunker arrangement is that no watertight doors are required in the bunker ends, as each set of boilers has the necessary coal supply provided in the same watertight compartment, the watertight bulkheads dividing the boiler rooms being placed at the centre of the cross bunkers.

Ash Hoists and Ejectors.

THE arrangements for discharging ashes on each of the two new White Star liners consists of ten See's ash ejectors, of which there are two in each large boiler

Fig. 46.—Set of Boiler Uptakes.

room, placed as shown on Plate VI. The ash ejectors are worked by the large duplex feed pumps, placed in a separate room adjoining each boiler room. One of the See's ash ejectors is shown on the right-hand section of Fig. 44. The ashes are discharged by shovelling them into the hopper placed on the stokehold floor, whence they are drawn down by the rush of air to a water jet which is being discharged through the long inclined pipe shown, at a pressure of about 150 lb., the jet being maintained by the pump already referred to. The water jet carries the ashes up the inclined pipe till, at the upper

Bunker Arrangements.

THE arrangements in the *Olympic* and *Titanic* for loading and storing coal and feeding the coal to the stokeholds are the result of great experience. The bunkers consist of a 'tween deck space on each side of the ship between the lower and middle decks, into which the coal is first shipped and from thence distributed into the cross bunkers extending the full width of the vessel in each boiler room. The stokers obtain the coal from doors in the cross bunker end bulkheads at the stokehold level immediately opposite the furnaces (see Plate VI.),

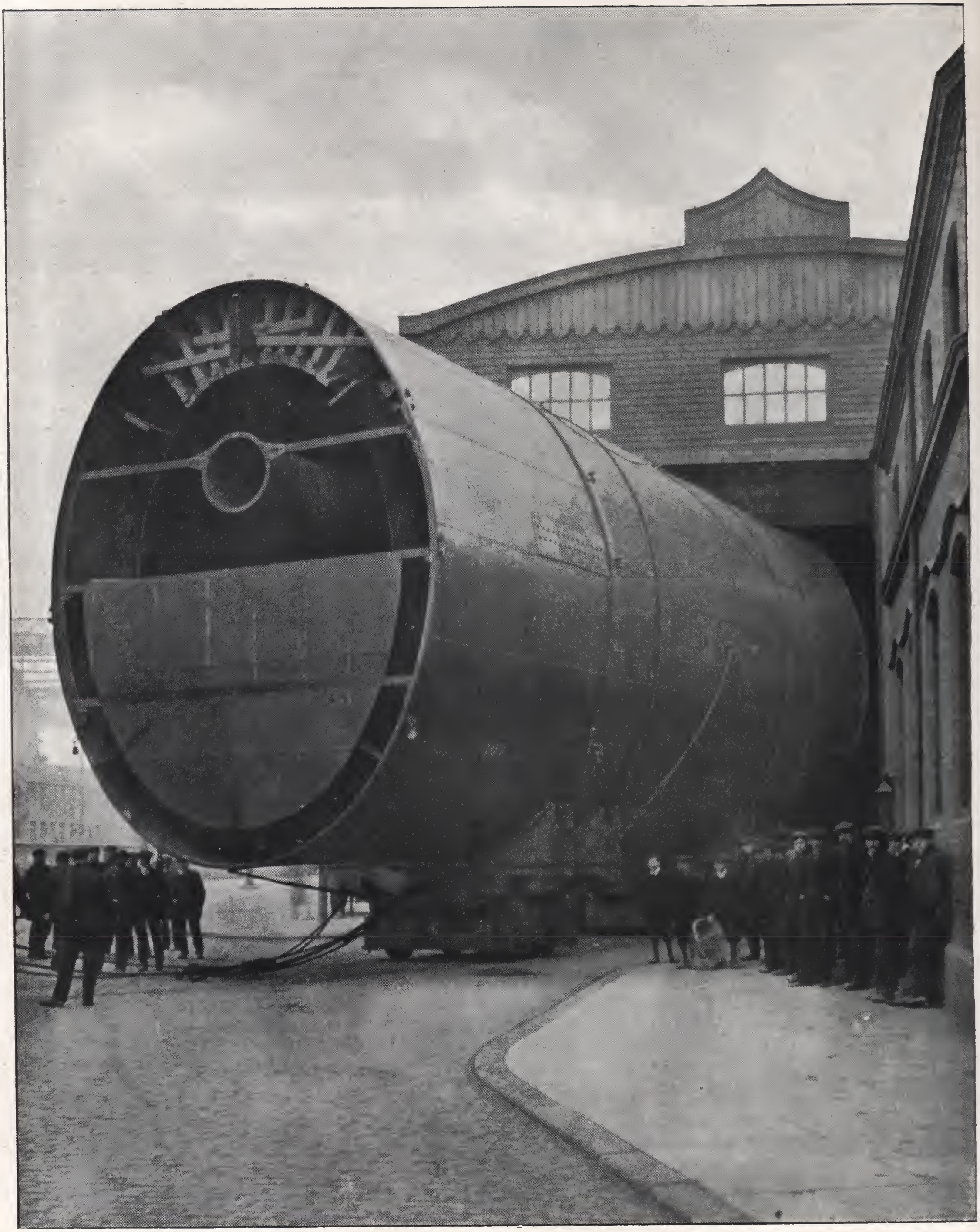


Fig. 47.—Last Funnel of the "Olympic" leaving the Shops.

bend, they are deflected and discharged well clear of the ship's side. In addition, there are four ash hoists supplied by Messrs. Railton, Campbell and Crawford, for use when the vessel is in port. Ash hoists of this type have proved remarkably free from wear and tear and require a very small

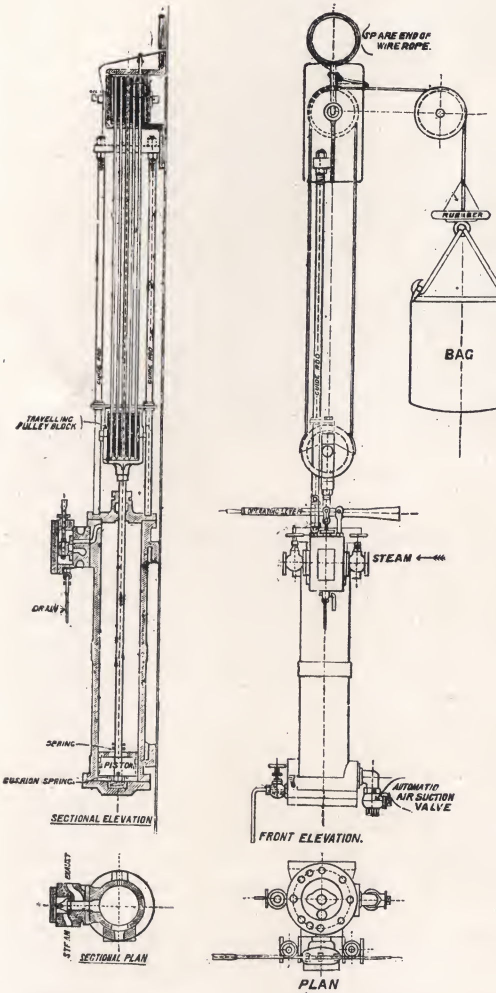


Fig. 48.—One of the Ash Hoists.

supply of steam, a $\frac{1}{4}$-in. pipe only being used for the steam inlet. Fig. 48 shows clearly their arrangement and method of working.

Induced Draught and Fans.

No forced draught is provided, it being the practice of the White Star Line to have forced ventilation only to the boiler rooms of their ships. For the latter purpose twelve Sirocco fans, two for each boiler room, have been supplied by Messrs. Davidson & Co., of Belfast, fitted with Allen motors. The fans are placed at the middle deck level and draw in air through ventilating shafts from the boat deck, supplying the same through trunks led down the bulkheads to the level of the furnaces. Eight of them are 55in. diameter, two 50in., and two 40in., a pair being illustrated by Fig. 49. One of the stokehold fan controllers with the cover removed is shown in Fig. 50. It will be seen that the cables are fitted permanently into screw plugs, the holes for which are bored and tapped in the joint of the cover, so that they can be placed in position and the cover screwed down, making a simple and yet watertight joint. The controllers can also be worked from the stokeholds by rods supported on ball thrusts. The ball thrusts so greatly eliminate friction that the different positions on the controller can be easily felt below.

Steam and Exhaust Pipes and Valves.

The steam supply is carried from the boilers to the engines by two main steam pipes made of welded steel, with a butt strap riveted over the weld, from which branches are carried to the various boilers, and which gradually increase in diameter as they approach the engine room forward bulkhead. On the forward side of this bulkhead, on each pipe line, is placed a balanced emergency stop valve (see Plate VI.), which can be closed in a few seconds in case of need. On the after side of the same bulkhead are the main stop valves, $21\frac{1}{2}$in. diameter (see Plates VII. and VIII.), each provided with a large separator and a cross connection, which allow either range of piping to be used for either or both engines. The main stop valves are of the equilibrium double-beat type, and are operated by hand wheels and screws from the starting platform, which is situated in the centre of the reciprocating engine room.

From the stop valves the steam passes to the reciprocating engines, and after expanding through the various stages is led from the low-pressure cylinders of each set by a 61-in. pipe to a huge change-over valve, 64in. diameter, situated on each side just abaft the forward bulkhead of the turbine room. By means of these change valves the exhaust steam is deflected downwards through large strainers to the turbine, or directly across to the condenser. The arrangement will be better understood by reference to Plates VII. and VIII. and the section through the turbine room given in Fig. 51, from which it will be seen that all these parts are in duplicate, there being an exhaust pipe, change-over valve, and steam admission to the turbine, and a main condenser on each side of the centre-line of the ship. The exhaust pipes, which have been supplied by Thos.

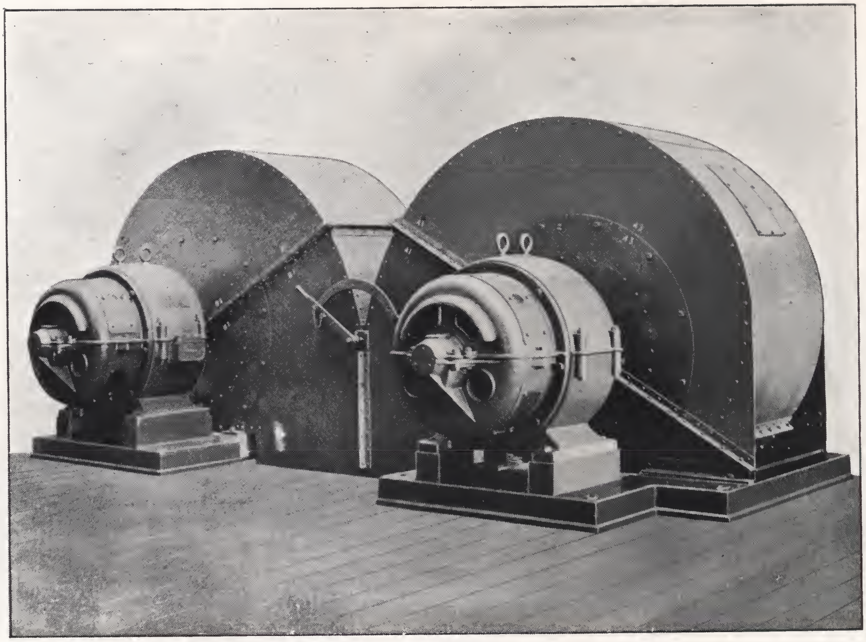


Fig. 49.—Two of the Stokehold Fans.

Piggott & Co., Ltd., of Birmingham, are of steel, lapwelded, with a strap riveted over the weld, and are provided with concertina or bellows joints between each rigid connection, to allow for expansion without endangering the airtightness of the pipes leading to the condensers. These joints consist of two thin steel discs riveted together at their periphery through a steel ring, and are about 2ft. 6in. larger in diameter than the pipes to which they are connected by flanges. The slightly conical form of the disc plates enables any difference in length due to contraction or expansion to be taken up.

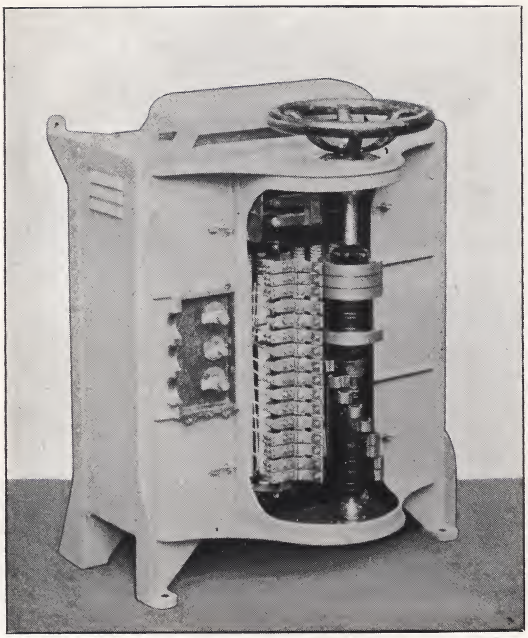


Fig. 50.—Stokehold Fan Controller, with Cover removed.

The change-over valves are of the piston type with a ring of special form. Fig. 52 illustrates the casing of one of these valves and clearly shows the ports. Steam is admitted to the strainer and thence to the turbine when the piston of the change-over valve is at its highest position, and to the condenser when the piston is lowered. The pistons of both change-over valves are connected to levers, the other ends of which (see Fig. 51) are controlled by a Brown's hydraulic reversing engine of the type adopted in reciprocating engine practice, which is in turn controlled by a lever on the starting platform close to the main reversing lever. When the order to reverse is given, the engineer at once pulls over the change-over valve reversing lever, the steam passes direct from the low-pressure cylinder to the condensers, and the machinery is handled as an ordinary reciprocating installation until the manœuvring is finished and steam is again admitted to the turbine by restoring the

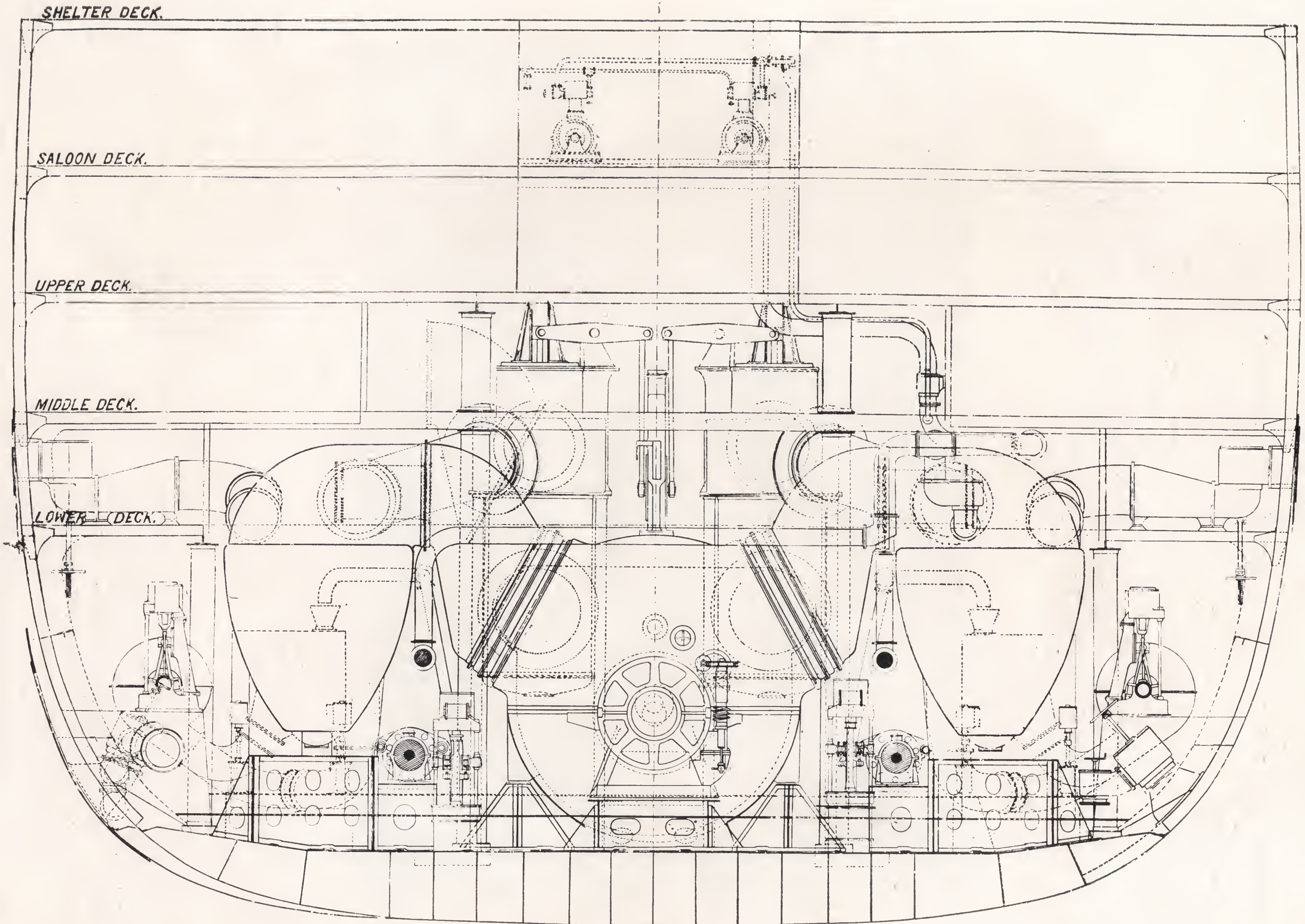


Fig. 51.—Section through Turbine Room.

change valves to their original position. From the turbine the steam exhausts to each condenser through large welded steel eduction pipes of rectangular section. Each pipe is provided with an immense sluice valve, 8ft. 6in. by 10ft. 6in., to shut off the turbine entirely from the condensers in case of accident to the former. These sluice valves are electrically operated, the closing slides, which are in two pieces, being worked together by worm and rack gear. To control the steam supply in case of the propellers racing or in the event of a break-down, each reciprocating engine is provided with an Aspinall governor which works in conjunction with a Brown's engine connected to the throttle valve, while in the case of the turbine a ball governor is provided, which controls the Brown's engine operating the change-over valves.

In regard to the auxiliary steam pipe system, it may briefly be said that the five single-ended boilers in No. 1 boiler room are arranged for running the auxiliary machinery when in port, while two boilers in each of the other compartments have separate steam leads to the auxiliary machinery, which includes the very large dynamo engines. The only auxiliaries exhausting into the main condensers are the steering engines. The electric engines exhaust through an independent pipe to the surface heater, and all other auxiliaries exhaust into the contact-heater. For port use a large auxiliary condenser is fitted.

The Reciprocating Engines.

The two sets of reciprocating engines are of the four-cylinder triple-expansion direct-acting inverted type, balanced on the Yarrow, Schlick and Tweedy system, and are arranged to take steam at 215lb. per sq. in. and exhaust at a pressure of about 9lb. per sq. in. absolute. The cylinders are 54in., 84in., 97in., and 97in. diameter, with a stroke of 75in. in all cases, and each set of engines is expected to indicate about 15,000 H.P. at 75 revolutions per minute. In general design the engines follow the long-tried practice of Messrs. Harland & Wolff. A section through the reciprocating engine room is given in Fig. 53, a view of the starboard engines erected in the shops in Fig. 54, and of the port intermediate cylinder in Fig. 55. From the elevation, Plate VII., it will be seen that the columns are of the "split" type, each column near its centre being divided into two sections which are well spread out to form a strong base. The engine bedplate weighs 195 tons, the columns 21 tons each, and the heaviest cylinder with liner

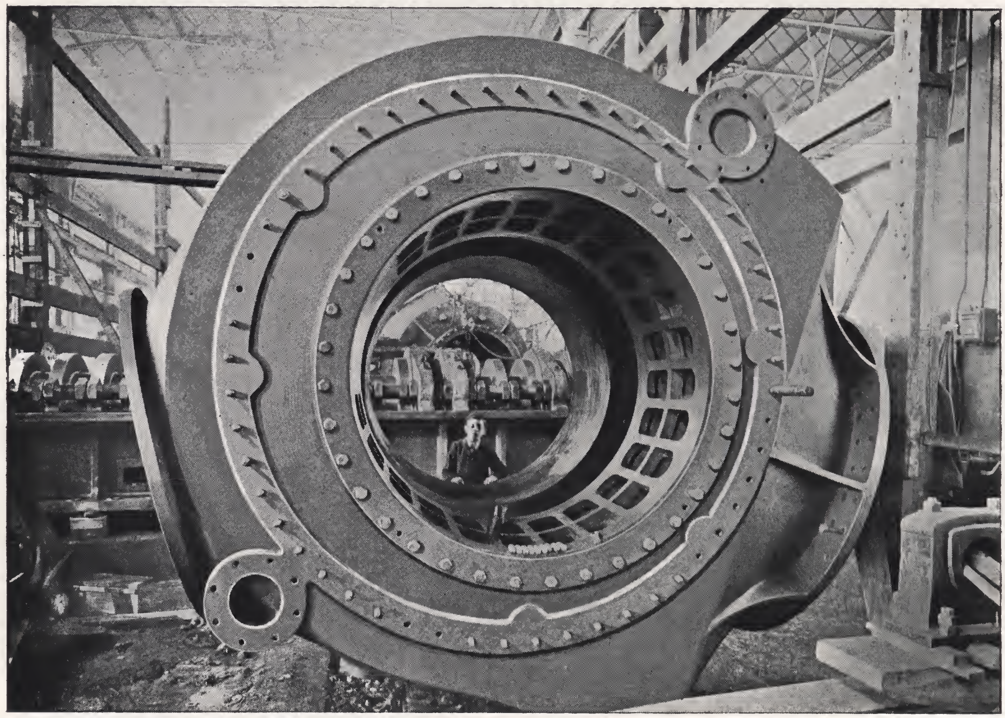


Fig. 52.—Casing of one of the Change-over Valves.

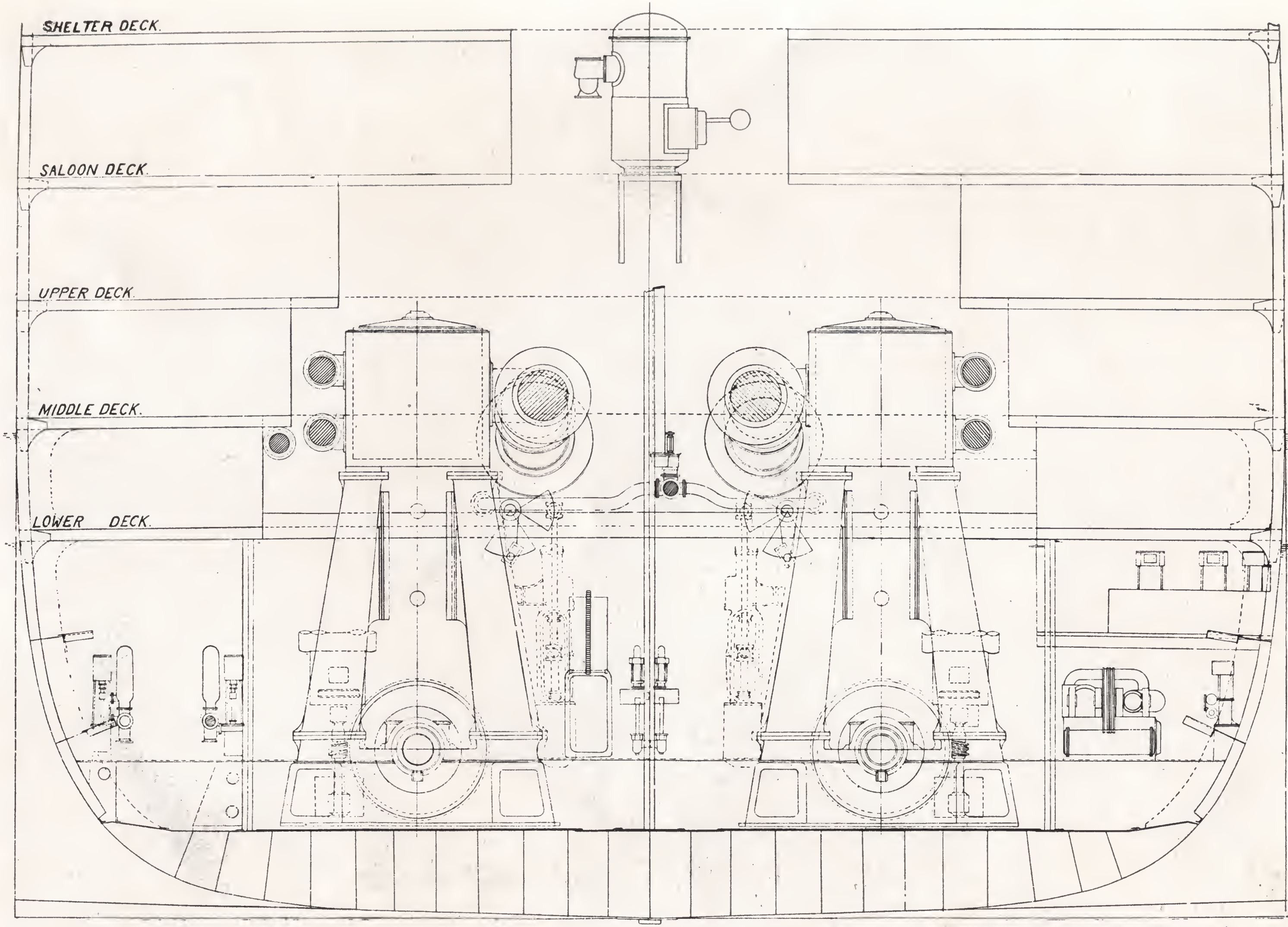


Fig. 53.—Section through Reciprocating Engine Room.

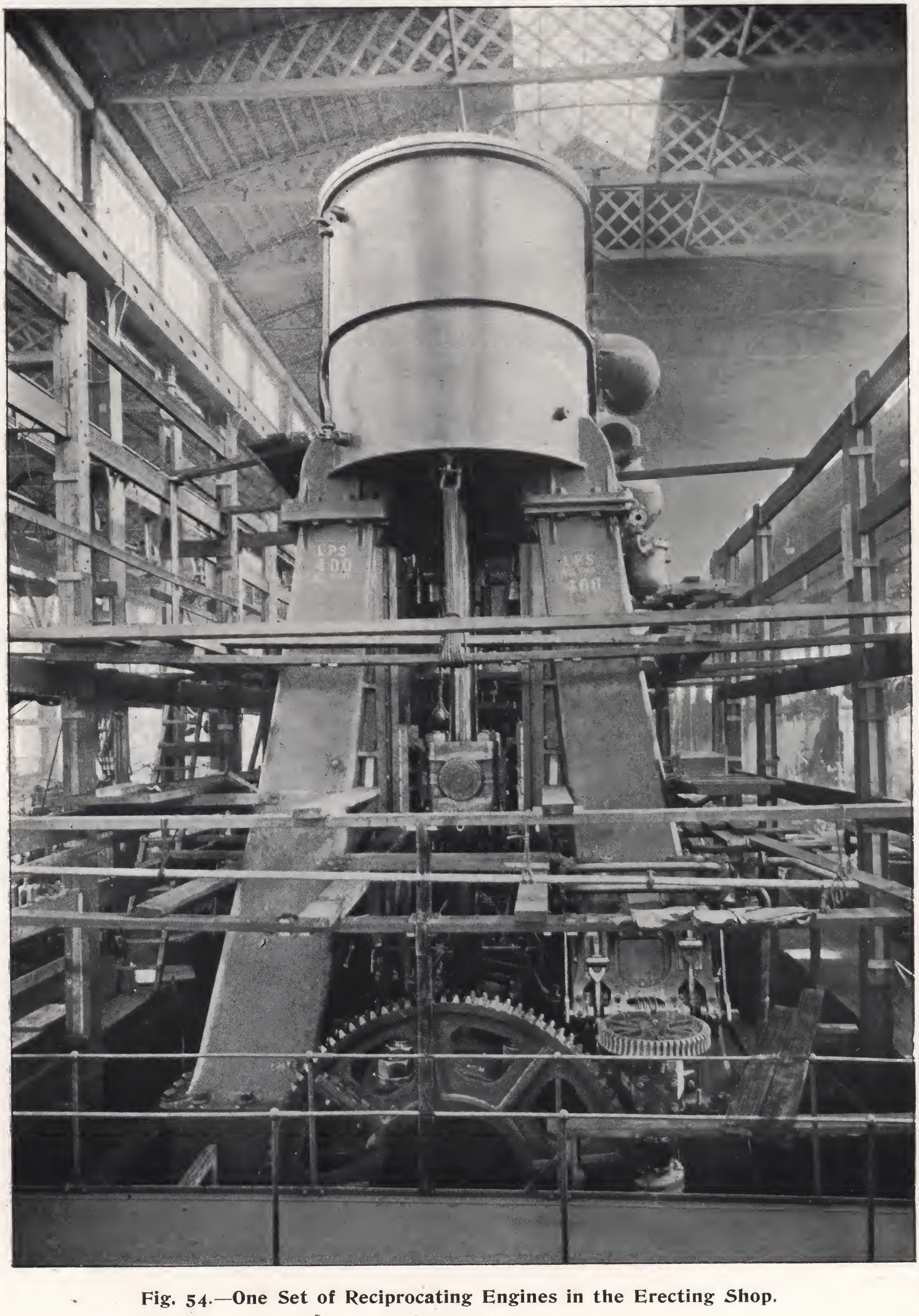


Fig. 54.—One Set of Reciprocating Engines in the Erecting Shop.

50 tons. The two low-pressure cylinders are placed one at each end of each set of engines, as is usual with the balancing system adopted, the order of the cylinders, beginning forward, being low-pressure, high-pressure, intermediate-pressure, and low-pressure; see Plates VII. and VIII.

Each L.P. cylinder is provided with two slide valves, worked from the same crosshead by a single set of double bar links and eccentrics. The H.P. cylinder is provided with a single piston valve and the I.P. cylinder with two piston valves similarly operated to the twin slide valves on the L.P. cylinders. The valves are operated by Stephenson link motion. The reversing gear for each set is operated by a Brown engine of the usual type, and, in order that the latter may always be at full stroke whatever the cut-off required in the various cylinders, each set of links has its own separate adjustment. Elaborate electrically-operated lifting gear for the cylinder covers, etc., has been necessitated owing to the great weights to be handled, while in addition several electric winches have been provided to deal with the smaller weights. The turning engines are steam-driven.

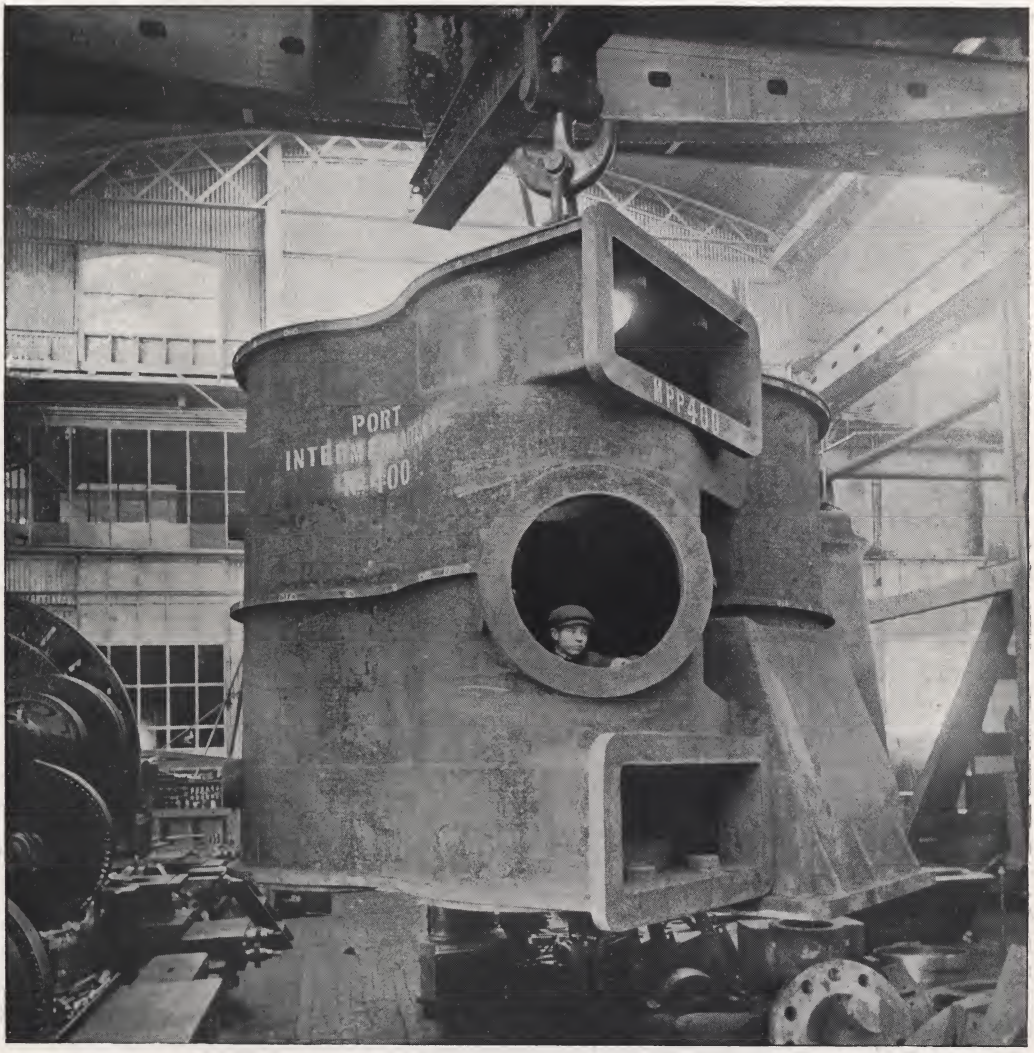


Fig. 55.—Port Intermediate Cylinder.

Low-Pressure Turbines.

THE low-pressure turbine, which is of the usual Parsons type, will take steam from the reciprocating engines at about 9 lb. absolute pressure and exhaust at 1 lb.

absolute. It is intended to develop about 16,000 shaft horse-power when running at 165 revs. per minute. No astern turbine has been fitted, as the centre shaft is put out of action when the ship is being manœuvred. The turbine, as will be seen from the illustrations, is of immense size, its weight complete being no less than 420 tons. The rotor is 12ft. diameter and 13ft. 8in. long between the extreme edges of the first and last ring of blades. It consists of steel forgings built up in the usual way, as illustrated in the photograph of the rotor in the lathe reproduced in Fig. 56. The rotor in process of blading is shown in Fig. 57. The blading is of the Parsons laced type, with distance pieces at the roots and binding soldered on the edge. The blades range in length from 18in. to 25½in. The complete rotor has a weight of about 130 tons. A view of the massive turbine casing, which is of cast iron, is shown in Fig. 58. Both hand and motor gear is provided for turning the turbine when under repair. The lifting gear for removing the upper half of the turbine casing is also electrically driven.

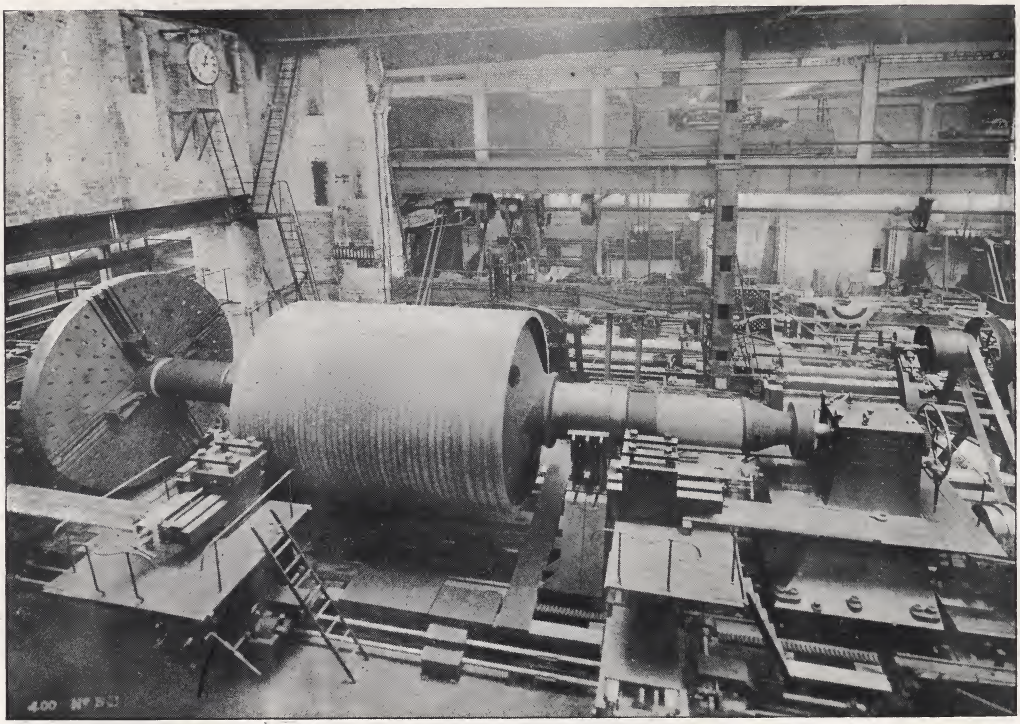


Fig. 56.—Turbine Rotor in the Lathe.

Shafting and Propellers.

The crank and thrust shafts for the reciprocating engines are 27in. diameter with a 9-in. hole through the centre. The line shafting is 26¼in. and tail-end shaft 28½in. diameter with a 12-in. hole through the centre. The crank shaft for each engine weighs 118 tons, its massive proportions being shown by Fig. 59, which illustrates part of a crank shaft in the lathe. One of the thrust shafts is shown in Fig. 60, from which it will be seen that there are fourteen collars provided, arranged seven at each end, with space for an intermediate bearing at the middle. Each tail shaft has a loose coupling to facilitate withdrawal outboard for examination. The turbine shaft is 20½in. diameter, increased at the tail-end to 22½in., with a 10-in. hole through the centre throughout.

The plummer blocks for the turbine shaft, of which there are eleven, are provided with forced lubrication at a pressure of about 20lb. per sq. in. The oil gravitates to the bearings from a tank placed high up on the casing, and of sufficient capacity to hold a ten minutes' supply. The oil escaping from the bearings is collected in two drain tanks placed beneath the engine room floor, from whence it is pumped back through filters and coolers to the supply tank. All the plummer blocks are also provided with a water-cooling service.

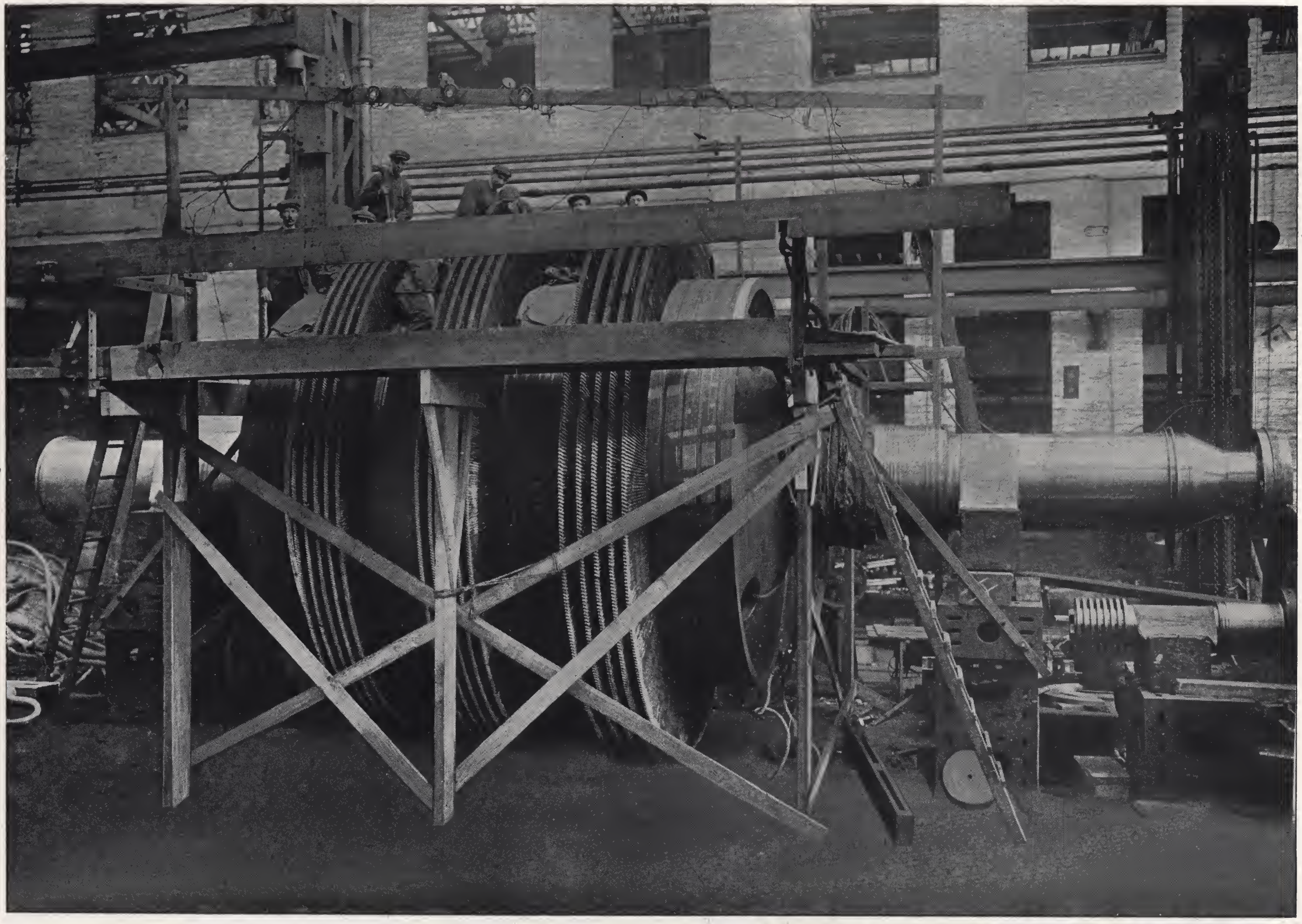


Fig. 57.—Turbine Rotor in Process of Blading.

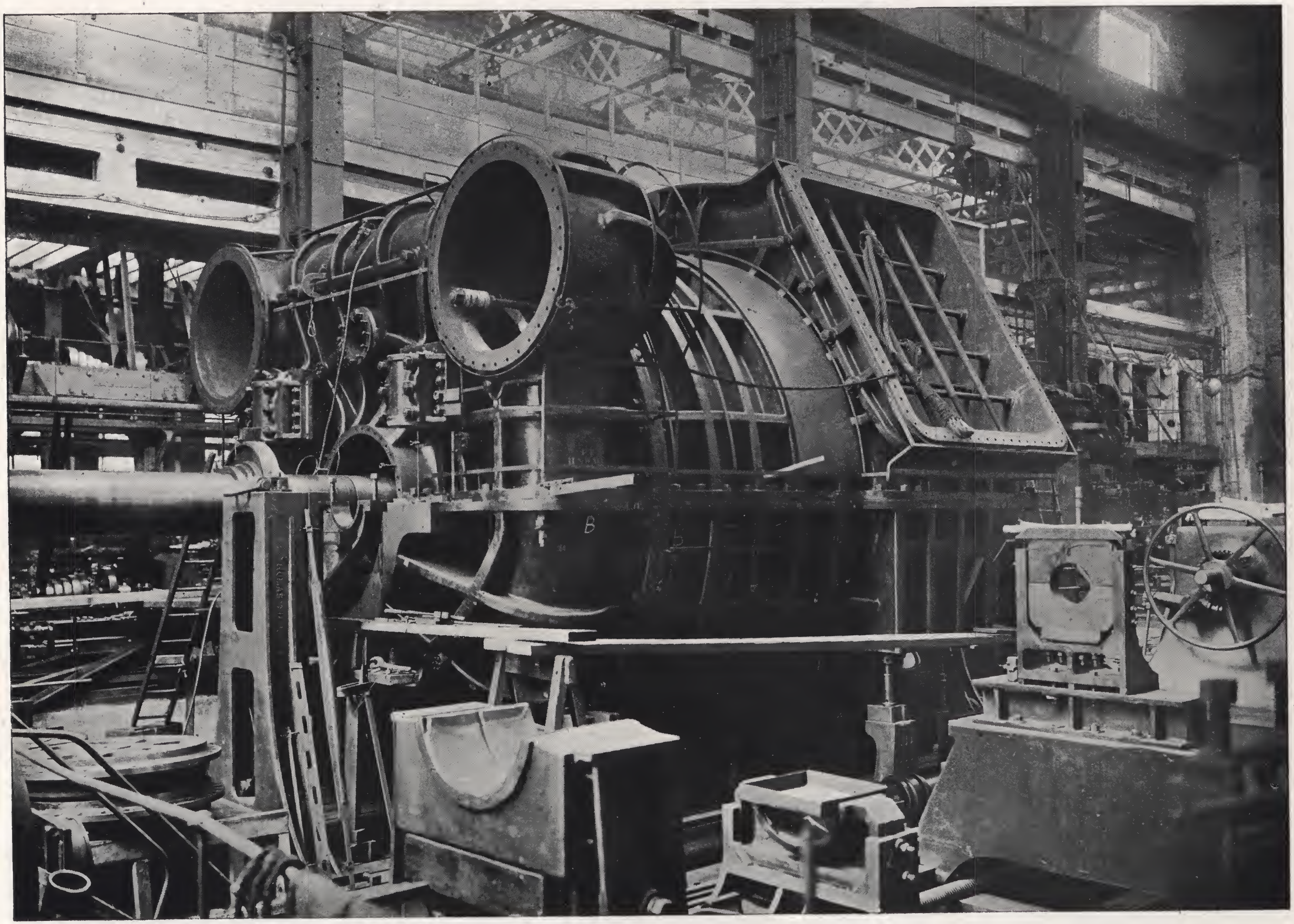


Fig. 58.—Turbine Casing.

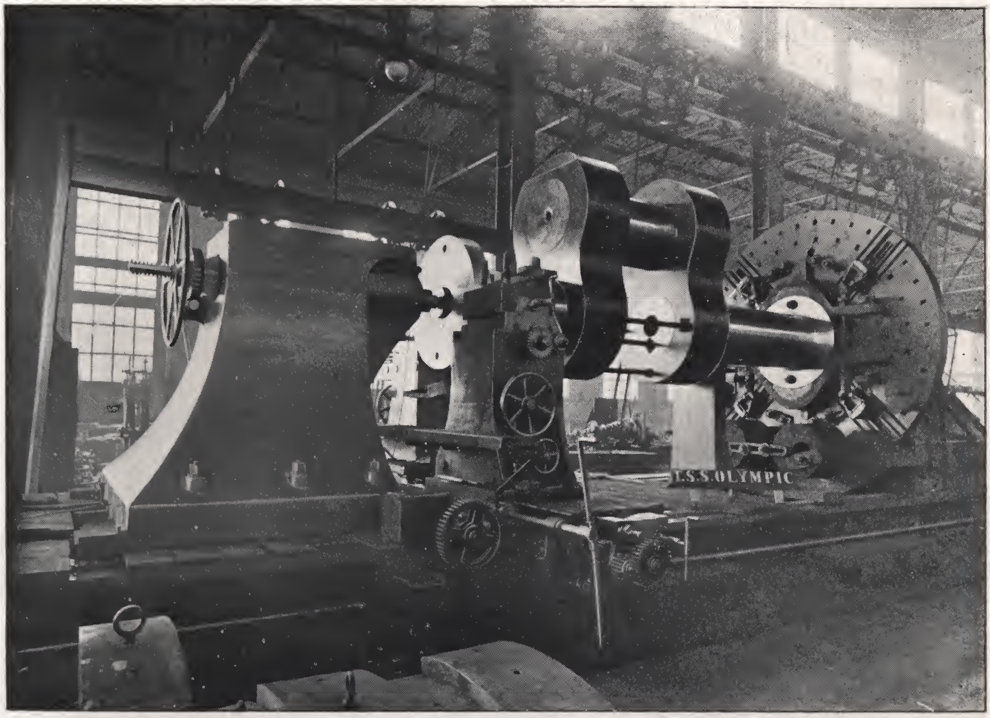


Fig. 59.—Crank Shaft in the Lathe.

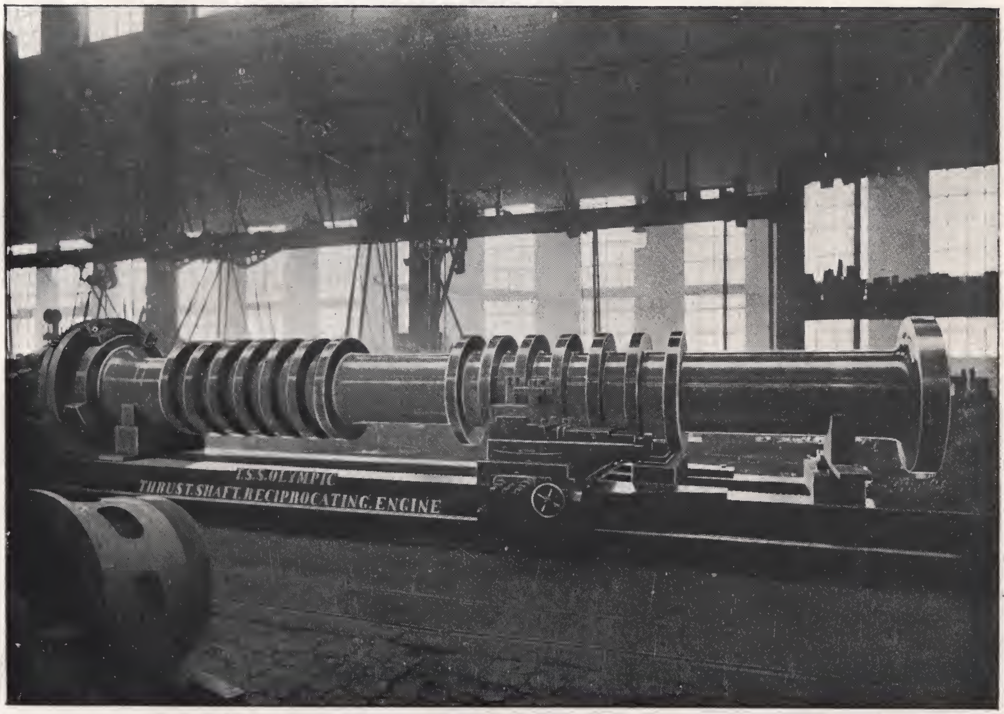


Fig. 60.—One of the Thrust Shafts.

The wing propellers of the *Olympic* are three-bladed and have a diameter of 23ft. 6in. The bosses are of cast steel and the blades of bronze. The centre or turbine propeller, which is illustrated by Fig. 61, has four blades and is built solid of manganeze bronze. The diameter in this case is 16ft. 6in.

Condensers.

The condensing plant has been designed to allow a vacuum of 28½in. with the barometer at 30in. and a temperature of circulating water of from 55 to 60° Fahrenheit. As already stated, there are two main condensers placed in the turbine engine room. They follow in design Messrs. Harland & Wolff's standard practice, and are pear-shaped in outline, as will be seen from Fig. 51 and the view of one of the condensers with the casing removed reproduced in Fig. 62, the object of the pear shape being to concentrate the tube surface where the largest volume of steam is admitted. The inlet extends the full length of the condenser, as is usual in turbine installations, and is well stayed vertically with division plates, which are in line with corresponding division plates in the condenser body, so that an equal distribution of steam over the whole of the tube area may be secured.

The auxiliary condenser, which is placed on the starboard side of the reciprocating engine room, is of similar design to the main condensers, and has a cooling surface of 3,600 sq. ft.

Circulating Pumps.

The circulating pumps have been constructed by Messrs. Harland & Wolff themselves. The main installation consists of four gunmetal pumps, two being placed on each side of the ship in the turbine room, for each main condenser, as shown on Plate VIII. The pumps have 29-in. inlet pipes and 5ft. 3in. impellers. Each is driven by a compound engine having cylinders 13in. and 22½in. diameter with a stroke of 15in. and working at 120lb. pressure. A plan of one complete pump and engine is given in Fig. 63. The auxiliary circulating pump, which is placed near the auxiliary condenser (see Plate VIII.), is of similar type. The inlet pipe in this case is 12-in. bore, and the engine has cylinders 8in. diameter with a stroke of 9in.

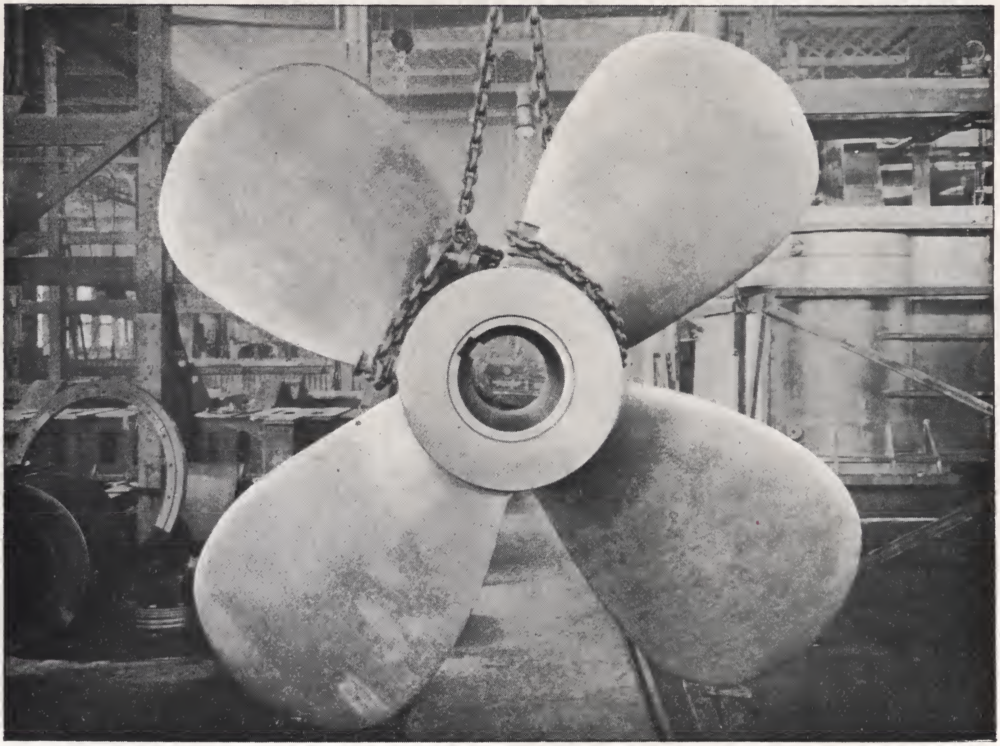


Fig. 61.—The Centre Propeller.

Air Pumps.

The main air pumps are placed in the turbine room adjoining the condensers, and have been supplied by Messrs. G. & J. Weir, Ltd. Altogether there are four pumps of the "Dual" type, illustrated in Fig. 64, each suitable for

about 11,000 I.H.P., and having both air and water barrels 36in. diameter by 21in. stroke. The pump barrels are of gunmetal, with cast iron bases and tops, and are fitted with gunmetal buckets, manganeze bronze pump rods, steel piston rods, and Kinghorn valves in gunmetal seats. The pumps are capable of performing their duty with a steam pressure of 120lb. per sq. in., but the steam cylinders can withstand the full boiler pressure of 215lb.

An independent twin air pump 17in. dia. by 15in. stroke, worked by a single steam cylinder 10in. dia. by 15in. stroke, is provided in conjunction with the auxiliary condenser.

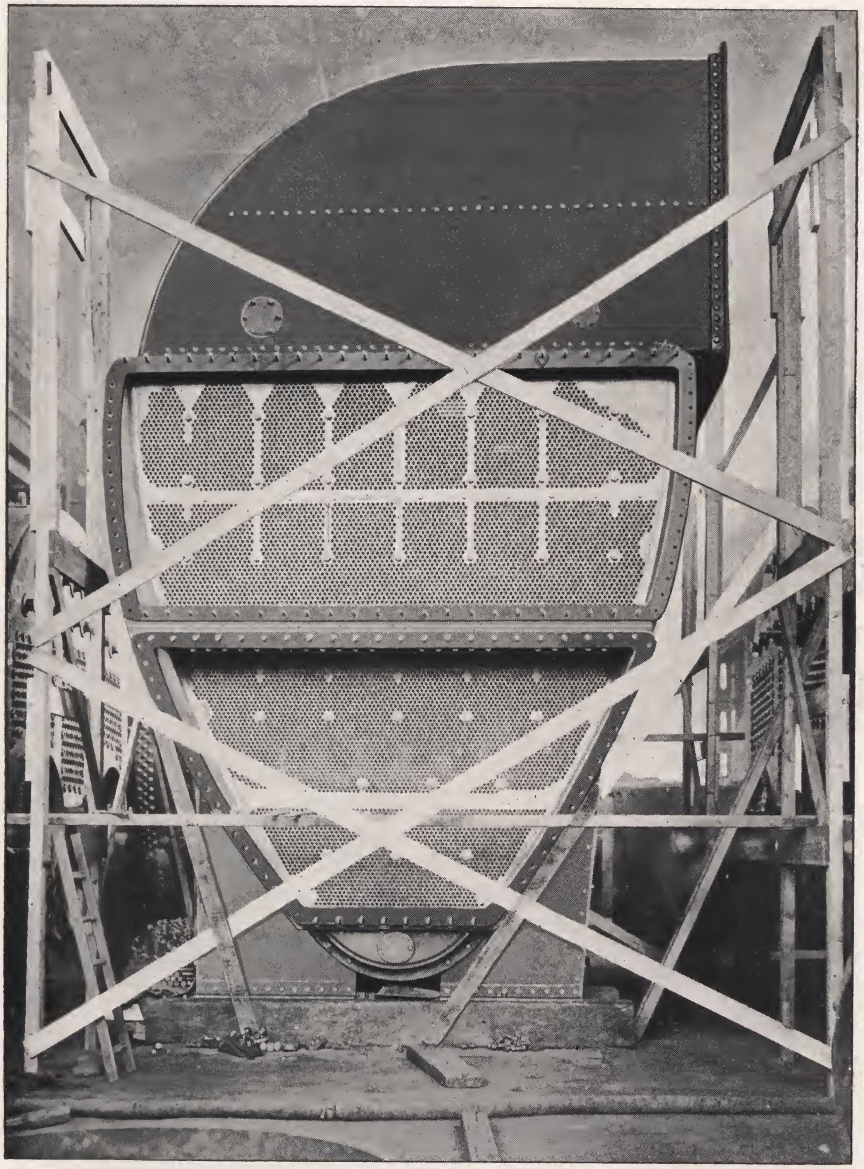


Fig. 62.—One of the Main Condensers with Casing partly removed

The Return Feed System.

From each condenser the water passes into a feed tank placed on each side of the ship just abaft the bulkhead dividing the engine rooms. From thence the water drains into a control tank on each side adjacent to the

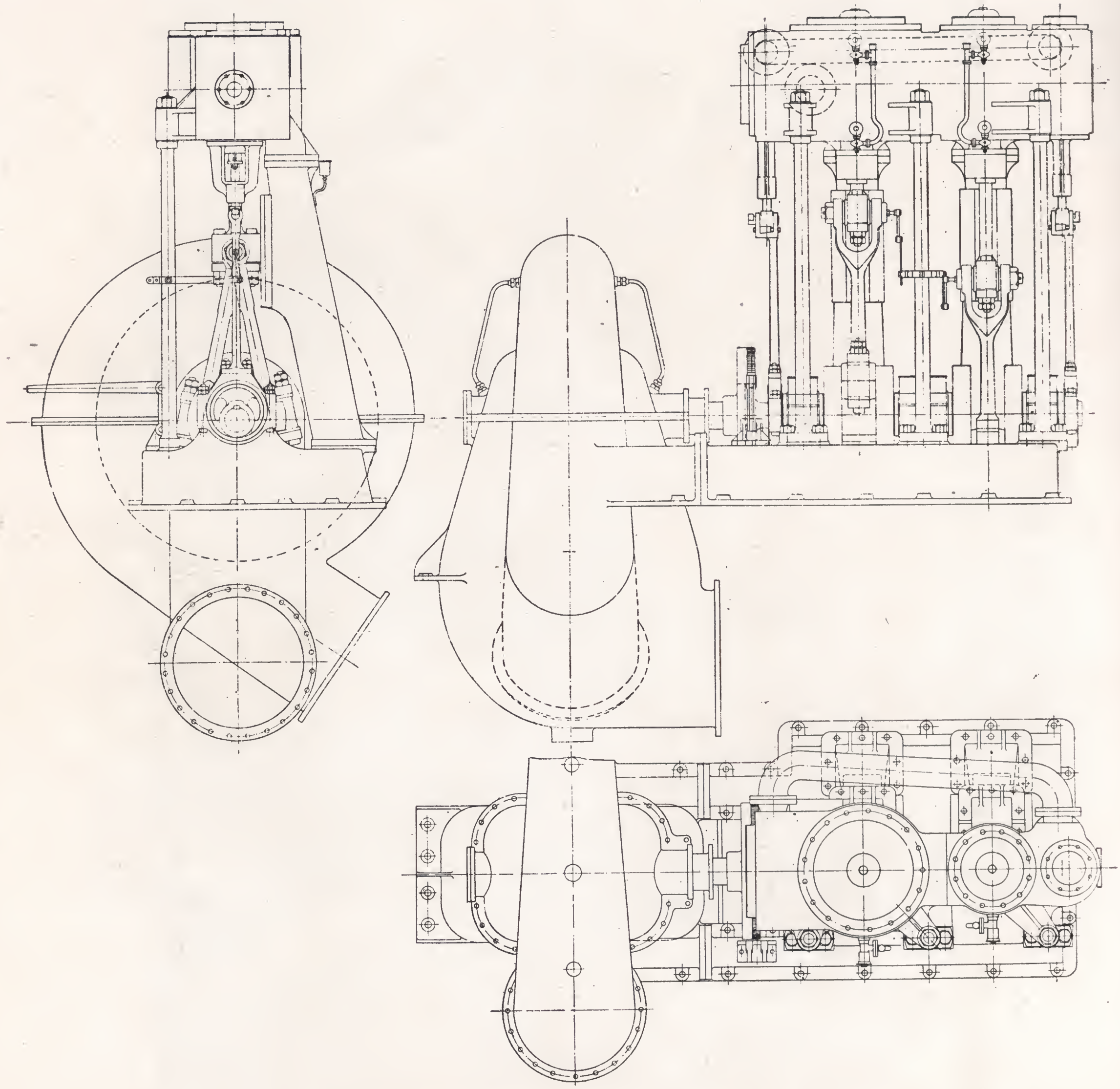


Fig. 63.—One of the Main Circulating Pumps and Engines.

hotwell pumps in the reciprocating engine room. From the control tanks the water is drawn by four Weir single-cylinder direct-acting hotwell pumps (two on each side of the ship) 14in. diameter by 24in. stroke, the diameter of the steam cylinder being 14in., and is discharged through the main feed filters to the Weir surface feed-heater. The main feed filters are placed against the forward engine room bulkhead (see Plate VIII.) and are four in number, two on each side of the ship. They have been supplied by Messrs. Railton, Campbell and Crawford, and the *Titanic* set is illustrated in Fig. 65. The total filtering area is 1,008 square feet.

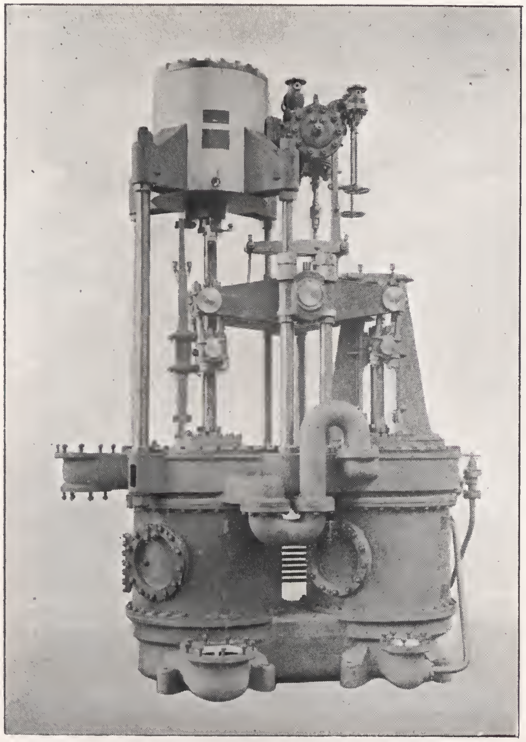


Fig. 64.—One Set of "Dual" Twin Air Pumps.

The surface feed-heater is capable of dealing with 700,000lb. of water per hour when supplied with 50,000lb. of exhaust steam per hour from the dynamo engines at a pressure of about 5lb. per sq. in., the temperature of the water being raised from 70° to 140°. The surface heater shell is of mild steel, the doors of cast iron, the tube plates of rolled brass, and the tubes of solid drawn brass. From the surface feed-heater the water passes to the direct-contact heater, placed high on the engine room forward bulkhead; see Plate VII. The direct-contact heater is suitable for dealing with 700,000lb. of feed water per hour, and when using exhaust steam from the auxiliaries is capable of raising the temperature of the feed water from 140° F. to 212 or 230° F. An illustration of this heater is given in Fig. 66. The shell is of mild steel. The direct-contact heater is so arranged that it will automatically regulate the feed pumps and hotwell pumps, and thus ensure these auxiliaries working in unison. From the contact heater the water gravitates to the main feed pumps, which are of Weir's vertical direct-acting type having a diameter of 14in. by 28in. stroke and steam cylinders of 19in. Four pairs of pumps are provided, but two pairs alone are capable of dealing with all feed water for 44,000 I.H.P. An illustration of one pair of the feed pumps is given in Fig. 67. In the case of both the main feed and the hotwell pumps, the water ends are of cast iron and are fitted with gunmetal liners, gunmetal buckets, manganeze bronze pump rods, and bronze valves in gunmetal seats. The water valve chests for the feed pumps are of cast iron, bolted to the pump chambers.

All the feed pumps are interchangeable so far as feeding the boilers is concerned. In addition to the main feed pumps, a large duplex pump of Messrs. Harland & Wolff's own make—intended for auxiliary feed purposes, working the ash ejectors, boiler circulation, and other duties—is placed adjacent to each boiler room (see Plate VI.) in a separate dust-tight compartment, so that the working parts may not be injuriously affected by coal dust.

Evaporating Plant.

The evaporators, three in number, are placed on the starboard side at the after end of the turbine room; see Plate VIII. They are of the latest Quiggin's type, and have been supplied by the Liverpool Engineering and Condenser Co. Two of them are shown in Fig. 68. Each evaporator has capacity for the production of 60 tons of distilled water per 24 hours, which can be maintained even after being in use for several days. The heating surface in each case is of the flat grid type, made from solid drawn copper tubes, and the shell is of cast iron. Each heating surface unit is interchangeable and can be separately withdrawn from the evaporator. The joints are of the grooved type. Being metal to metal, they do not require any jointing material, and are perfectly tight under any pressure and variation of temperature. The shells are lagged with double-ply hair felt and sheathed with galvanized sheet iron. An independent duplex steam feed pump supplies the evaporators with feed water, the supply being automatically controlled by the automatic regulator fitted for this purpose on each evaporator.

Sundry Pumps.

SPACE does not permit a detailed reference to the very numerous pumps provided and their duties. Many of these pumps have been made by Messrs. Harland and Wolff, Ltd., while others have been supplied by Messrs. G. & J. Weir, Ltd. Notable among the latter are three direct-acting fresh-water pumps, each capable of dealing with 5,100 gallons of water per hour when running at 30 double strokes per minute, and one fresh-water pump capable of dealing with 2,800 gallons per hour

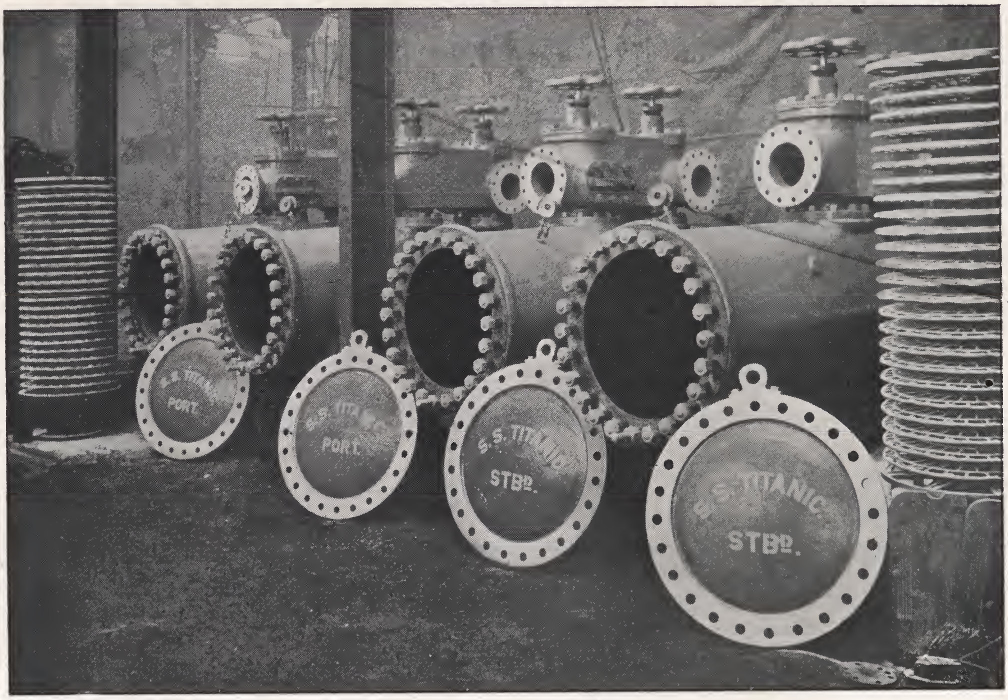


Fig. 65.—Main Feed Filters of the "Titanic."

when running at the same speed. Messrs. Weir have also supplied the three single-cylinder oil pumps used in connection with the forced lubrication system, and which are capable of discharging oil through a cooler to a head of about 90 feet.

Telegraphs.

THE engine telegraphs for transmitting orders from the captain's bridge to the starting platform are of the usual type fitted in large vessels and call for no special comment.

A system of illuminated telegraphs has been provided between the starting platform and the various boiler rooms to enable the engineer on watch to communicate his orders to each stokehold. With eleven stokeholds to control, the foremost of which is 320ft. from the engine room, the necessity for such an arrangement is evident. Fig. 69 shows the transmitter and one of the receivers belonging to the installation, which has been supplied by Messrs. Evershed & Vignoles, Ltd., of London. The same firm have also supplied a set of Kilroy's stoking indicators for each stokehold, of which a regulator and one of the indicators are illustrated in Fig. 70. The regulator is set to the rate of firing desired by the engineer, and the indicators, which are electrically operated by current switched on from the ship's circuit, give visible and audible intimation to the fireman at the exact moment when each furnace is to be fired. Five indicators are provided in each stokehold, one for each boiler, and are regulated so that the minimum number of furnace doors will be open at the same time, and no opposite doors in a double-ended boiler open together.

Whistles.

THE whistles are the largest ever made. Each set consists of three bell domes grouped together with a suitable branch plate, as shown

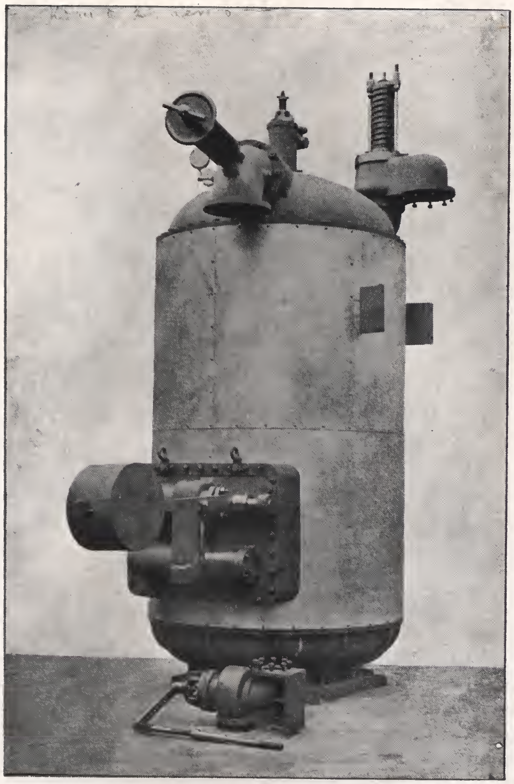


Fig. 66.—Direct-Contact Heater.

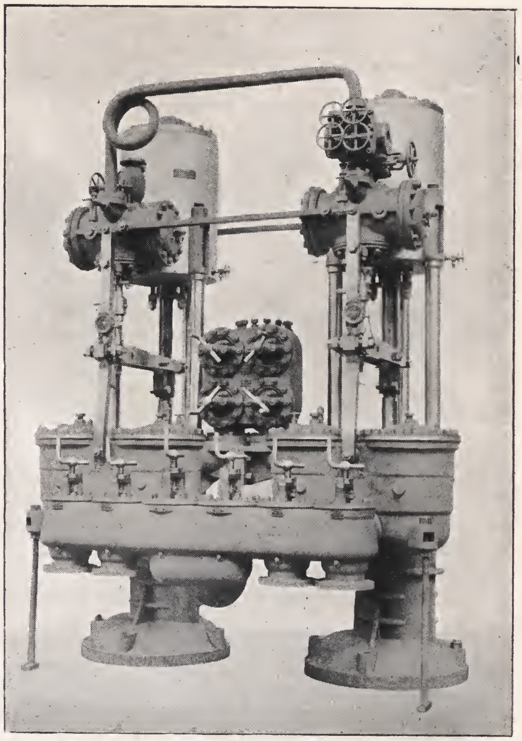


Fig. 67.—One Pair of Vertical Direct-Acting Feed Pumps.

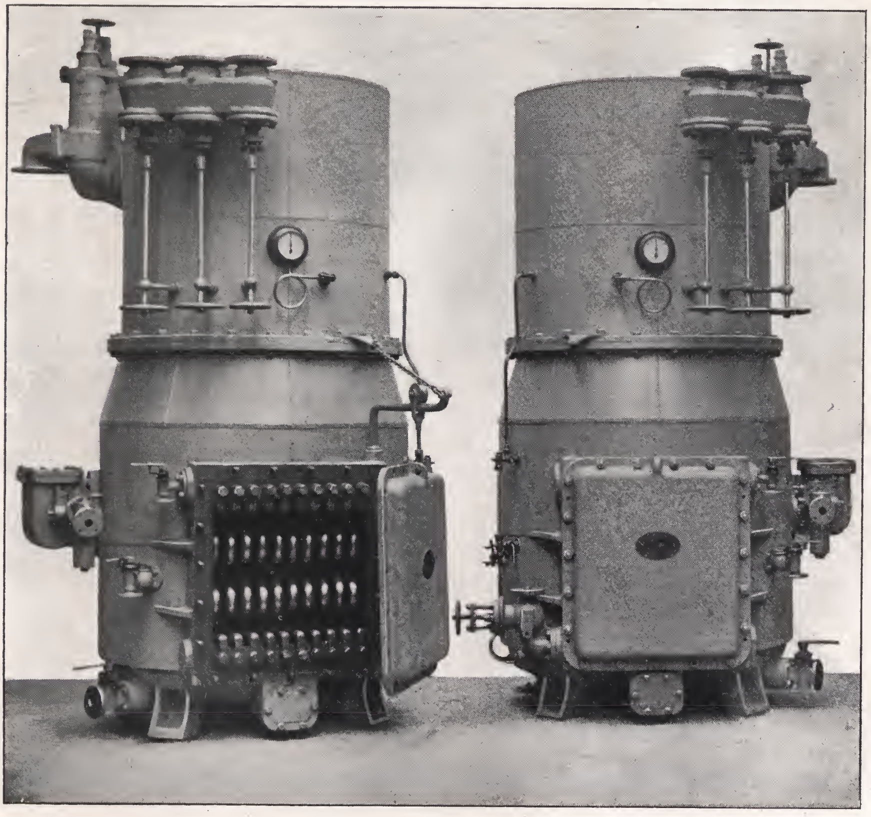
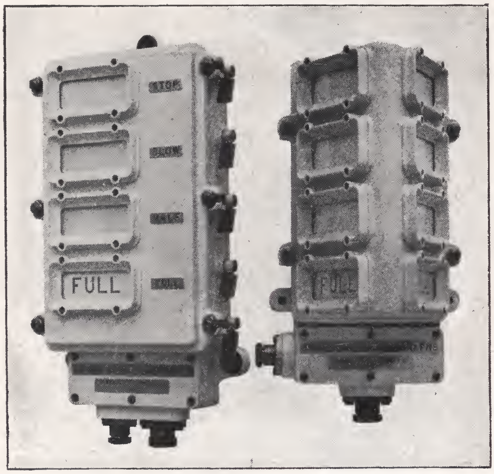


Fig. 68.—Two of the Evaporators.



Transmitter. Receiver.

Fig. 69.—Boiler Room Telegraph.

Regulator. Indicator.

Fig. 70.—Kilroy's Stoking Indicator.

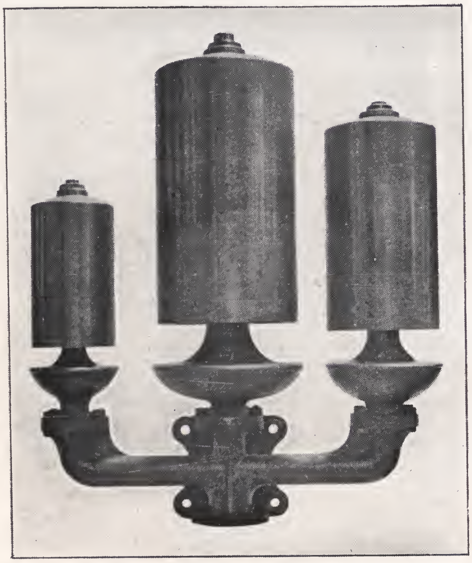


Fig. 71.—One Set of Whistles.

in Fig. 71. The three domes are 9in., 15in., and 12in. diameter. The total height from the base of the branch piece to the top of the centre dome is 4ft. $2\frac{1}{2}$in., and the extreme width over the outer dome is 3ft. 6in. The total weight of the three domes and branch pieces is about $6\frac{3}{4}$cwt. One set has been fitted on each of the two foremost funnels. The whistles are electrically operated, the officer on the bridge having merely to close a switch to give the blast, and there is also an electric time-control arrangement, fitted on the Willett-Bruce system, whereby the whistles are automatically blown for 8 to 10 seconds every minute during thick weather.

Ventilation of the Engine Rooms.

Over the reciprocating engine room is situated the usual light and air shaft, which extends above the boat deck and is surmounted by a large skylight. The similar shaft from the turbine room is surmounted by the fourth funnel, which is a most valuable adjunct for ventilating purposes.

The ventilation of the engine rooms is further assisted by four electrically-driven Sirocco fans, of which three are placed in the reciprocating engine room and one in the turbine room. All are 30in. diameter and of the discharge type. Of the three fans in the reciprocating engine room, one is placed in the skylight and supplies air in the vicinity of the starting platform through a series of trunks, while the other two are situated on the port and starboard sides respectively and ventilate the wings. The single fan in the turbine room is used for ventilating the wings of that compartment.

The Refrigerating Installation.

THE refrigerating installation on board the *Olympic* and *Titanic* embodies all the latest facilities for efficient cold storage. The ship's provision rooms, situated aft on the lower and orlop decks (see Plate V.), are most extensive, and include separate cold chambers for beef, mutton, poultry and game, fish, vegetables, fruit, milk and butter, bacon and cheese, flowers, mineral waters, wine and spirits, and champagne, which can thus be kept at the temperatures most suitable for preservation in each case.

A large insulated compartment for the carriage of perishable cargo occupies an adjacent space to the provision stores. The installation also comprises a number of cold larders in the bars and pantries in different parts of the ship, and arrangements for making ice and cooling the drinking water which is supplied at various points in the first, second, and third-class accommodation.

The refrigerating engines, which, with their accessories, have been supplied by Messrs. J. & E. Hall, Limited, of Dartford, are situated on the port side of the reciprocating engine room at the floor level; see Plates V. and VIII. The engines (Fig. 72) consist of two horizontal duplex CO_2 machines, each of which combines two complete units capable of independent working, so that actually four refrigerating units are provided. The machines are of the makers' standard type, having compressors bored from solid blocks of high-carbon steel, and condenser coils of solid drawn copper contained in the base casting. Each machine has its own surface condenser, brass circulating pumps, and air and feed pumps. A duplex brass-ended water pump is provided as a stand-by.

The evaporators, likewise divided into four units, are placed in an insulated recess above the machines at the orlop deck level, at which level the brine pumps—three in number, with interchangeable connections—are also placed. The brine return tanks are situated at the lower deck level, immediately above the evaporators; see Plate V.

The brine circulation is on the open return system, with separate flow and return on each circuit. All brine pipes throughout are externally galvanized. The various circuits are of moderate length, and are interlaced in the chambers to ensure even distribution of the cooling effect, even in the remote contingency of one section becoming blocked.

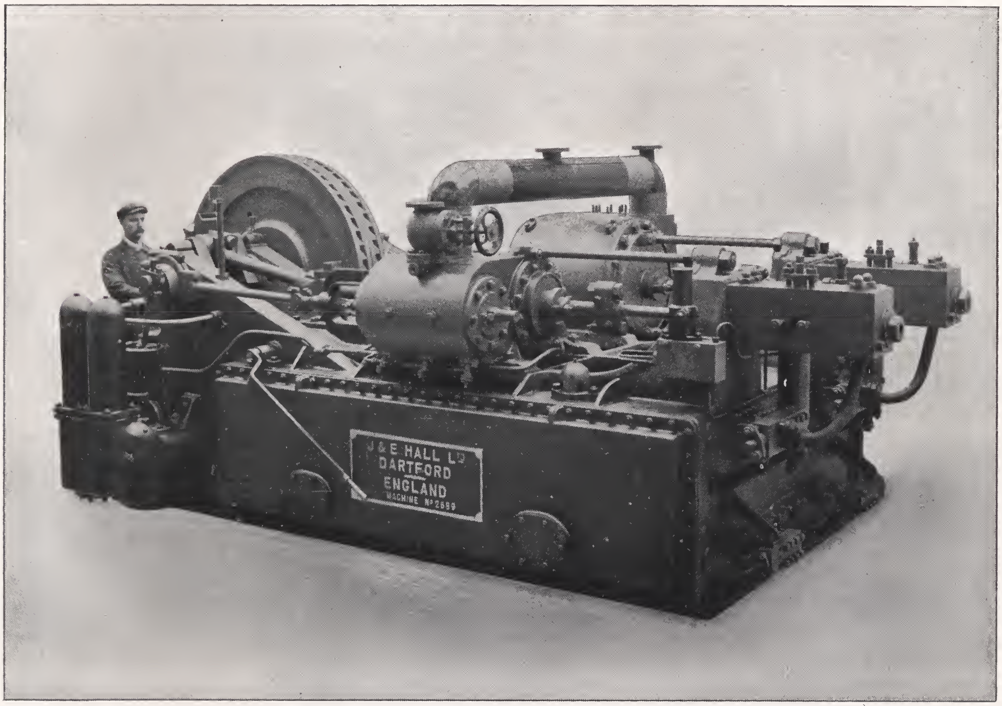


Fig. 72.—One of the Refrigerating Engines.

Passenger Accommodation.

FULL advantage has been taken of the great size of the *Olympic* and *Titanic* to provide passenger accommodation of unrivalled extent and magnificence. As will be seen from the deck plans reproduced in Plates III., IV. and V., the arrangement has been most carefully considered from all points of view, and the excellent result achieved defies improvement. About 2,440 passengers can be accommodated in each ship, so that, with her crew of about 860, she carries a grand total of 3,300 persons. A summary of the number of passengers of each class and the rooms provided on the various decks is given in Table VI. The general scheme of decoration is similar in both ships; so that, although our illustrations in this section for the most part represent the passenger accommodation of the *Olympic*, they may also be taken as indicating the appearance of the public rooms, staterooms, etc., of the *Titanic* when that vessel is completed.

First-class Accommodation.

THE accommodation for first-class passengers is placed amidships and extends over five decks, as shown in Plates III. and IV., the promenade (A), bridge (B), shelter (C), saloon (D), and upper (E) decks. Access from one deck to another is obtained by means of the two grand staircases, and other smaller stairways, and by three electric elevators adjacent to the forward staircase, which travel from the upper to the promenade deck. The first-class public rooms include the dining saloon, reception room, restaurant, lounge, reading and writing room, smoking room, and the verandah cafés and palm courts. Other novel features are the gymnasium, squash racket court, Turkish and electric baths,

TABLE VI.

	Number of Rooms.				No. of Passengers.
	One-berth.	Two-berth.	Three-berth.	Parlour Suite Sitting Rooms.	
First-class.					
A deck	30	...	4	...	42
B ,,	31	34	8	2	123
C ,,	15	62	57	2	310
D ,,	11	8	30	...	117
E ,,	9	2	28	...	97
Total	96	106	127	4	689

If required, 46 single-berth rooms can be converted into two-berth rooms, making the total number of first-class passengers 735.

	Two-berth.	Three-berth.	Four-berth.	No. of Passengers.
Second-class.				
D deck	19	...	20	118
E ,,	15	...	49	226
F ,,	19	...	45	218
G ,,	23	2	15	112
Total	76	2	129	674

THIRD-CLASS.	Two-berth.	Four-berth.	Six-berth.	Eight-berth.	Ten-berth.	No. of Passengers.
D Deck	4	...	7	...	...	50
E "	26	40	8	...	...	260
F "	31	59	18	5	2	466
G "	5	13	4	...	...	86
G " forward, open berths	...	...	...	...	...	164
Total	66	112	37	5	2	1026

SUMMARY.

	Number of Rooms.		Number of Passengers.
First-class	333	......	735
Second-class	207	......	674
Third-class in rooms......	222	......	862
" in open berths	—	......	164
Total.........	762 rooms		2435 passengers.

and the swimming bath. Magnificent suites of rooms, and cabins of size and style sufficiently diverse to suit the likes and dislikes of any passenger, are provided. There is also a large barber's shop, a dark room for photographers, a clothes-pressing room, a special dining room for maids and valets, a lending library, a telephone system, and a wireless telegraphy installation. Indeed everything has been done in regard to the furniture and fittings to make the first-class accommodation more than equal to that provided in the finest hotels on shore.

Grand Entrances and Staircases.

The forward main staircase is situated between the first and second funnels from forward, and extends from the middle to the boat decks, with large entrance halls at each level; see Fig. 73. It is over 60ft. in height and 16ft. wide. The style is early English of the time of William and Mary; but instead of the heavily carved balustrade usual at that period, wrought iron scroll work has been adopted, somewhat after the French style of Louis XIV., and occasionally seen in contemporary great houses in England. The iron work is relieved by occasional touches of bronze in the form of flowers and foliage. The walls are covered with oak panelling, simple and dignified in character, but enriched in a few places by exquisite work reminiscent of the days when Grinling Gibbons collaborated with his great contemporary, Wren. The staircase is lighted by a large dome of iron and glass, beneath which, on the uppermost landing, a large carved panel gives a tone of richness to the otherwise plain and massive construction of the wall. The panel contains a clock, on either side of which is a female figure, the whole symbolising Honour and Glory crowning Time. The three elevators, the mechanical arrangement of which is described elsewhere, are placed just forward of this staircase, as will be seen from the deck plans. They are entered from the forward end, the entrance halls on each deck being extended in this direction to provide ample space for ingress and egress, and harmonize in design with their surroundings; see Fig. 74.

The after main staircase is situated between the third and fourth funnels from forward. It is in style exactly similar to the forward staircase, but extends only from the promenade to the shelter decks.

First-class Dining Saloon.

The first-class dining saloon is situated upon the saloon deck amidships and is an immense room, by far the largest afloat, extending for the full 92ft. of the ship's width and 114ft. in length. The style adopted is Jacobean English of the early seventeenth century, for details the splendid decorations at Hatfield, Haddon Hall, and other great houses of that period having been carefully studied; but instead of the sombre oak, which the sixteenth and seventeenth century builders would have adopted, the walls and ceiling have been painted white. The ceiling in particular is richly moulded in a manner characteristic of the plasterer's art of Jacobean times. The superb effect achieved is well conveyed to the mind by the picture of the saloon reproduced in Plate II., but a complete perception of its magnificence can only be obtained by actual presence on the ship when dinner is in progress. The sidelights in the shell of the vessel are in groups of six and four

Fig. 73.—Main Staircase and Entrance Hall on Promenade Deck.

lights alternately, each light being of large diameter. In front of these lights inside the saloon large leaded glass windows have been arranged as shown in Fig. 75, giving the effect of the windows in a large mansion. Dining accommodation is provided for 532 passengers at the same time. It will be seen from Plate II. and the plan view of Fig. 76 that the saloon is arranged on the popular restaurant principle with small tables. At the sides the tables are in recessed bays, which form in effect a number of separate private dining rooms, where families or friends can dine together practically alone, retired from the busy hum of surrounding conversation. The furniture is of oak, designed to harmonize with the surroundings and at the same time to avoid the austere disregard for comfort which evidently proved no hindrance to the enjoyment of a meal in Jacobean times. The sideboards are particularly handsome and in keeping with the general character of the room, as is also the piano. The floor is covered with linoleum tiles of a unique pattern. An important point in connection with the dining of such a large number of passengers, *viz.*, the service, has been carefully borne in mind, and at the after end of the saloon, extending the full width of the vessel, are two extensive pantries to ensure the maintenance of the traditions of the White Star Line for quick and efficient service.

The Reception Room.

The reception room (Fig. 77), which adjoins the forward end of the dining saloon (see Fig. 76), has a length of 54ft. and also extends the full width of the ship. The style adopted is Jacobean English similar to the dining room, but the furniture is, of course, different. The dignity and simplicity of the beautifully proportioned white panelling, delicately carved in low relief, will indeed form a fitting background to the brilliant scene when the passengers foregather before dining. The main staircase rises directly from this apartment, thus greatly increasing the palatial effect produced. Facing the staircase is a large and very beautiful panel of French tapestry adapted from one of a series entitled "Chasse de Guise" at the National Garde Meuble, and specially woven on the looms at Aubusson. The floor is covered with a dark, richly coloured Axminster carpet. The furniture includes capacious Chesterfields, grandfather chairs upholstered in a floral pattern of wool damask, comfortable cane chairs, and light tables distributed at intervals, and there is also a grand piano.

Fig. 74.—First-class Passenger Elevators.

Restaurant.

THE restaurant (Fig. 78), situated on the bridge deck, will be considered by many competent judges the most enticing apartment in the vessel. It is 60ft. long and 45ft. wide. The style of decoration adopted is that of the Louis Seize period. The room is panelled from floor to ceiling in beautifully marked French walnut of a delicate light fawn brown colour, the mouldings and ornaments being richly carved and gilded. Large electric light brackets, cast and finely chased in brass and gilt, and holding candle lamps, are fixed delicately modelled flowers in low relief combine to form a simple design of trellis in the centre and garlands in the bays. At various well-selected points hang clusters of lights ornamented with chased metal gilt and crystals. The floor is covered with an elegant pile carpet of Axminster make, having a non-obtrusive design of the Louis Seize period. The colour is a delicate *vieux rose* of the shade known as *Rose du Barri*, in perfect harmony with the surroundings.

Comfort has been well considered in the arrangement of the furniture. Small tables have

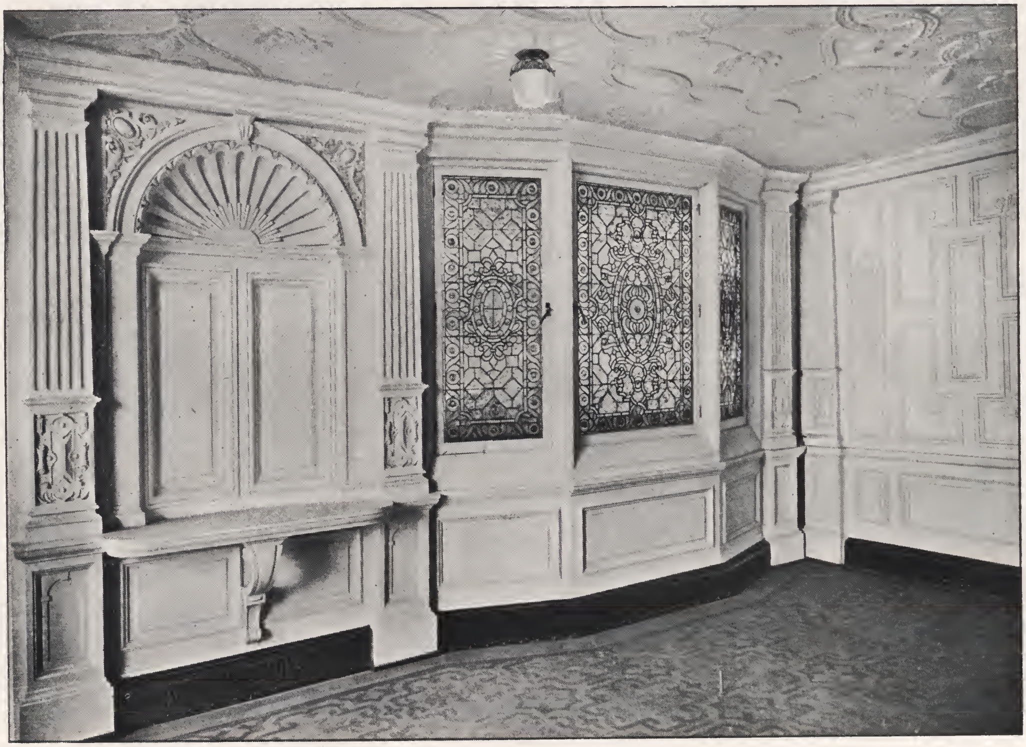


Fig. 75.—Bay Window in First-class Dining Saloon.

in the centre of the large panels. On the right of the entrance is a buffet with a marble top of *fleur de pêche*, supported by panelling and plaster recalling the design of the wall panels. The room is well lighted by large bay windows, a distinctive and novel feature which creates an impression of spaciousness. The windows are divided into squares by ornamental metal bars, and are draped with plain fawn silk curtains having flowered borders and richly embroidered *pelmets*. Every small detail, including even the fastenings and hinges, has been carried out with due regard to purity of style. The ceiling is of plaster, in which

been provided to accommodate from two to eight persons, and crystal standard lamps with rose-coloured shades illuminate each table. The chairs have been well studied, and are made in similar light French walnut to the walls. The woodwork is carved and finished with a waxed surface. The upholstery covering is Aubusson tapestry in quiet tones, representing a *treillage* of roses. For convenience of service there are several dumb waiters encircling the columns and forming part of the decorative scheme. A bandstand, partly recessed and raised on a platform, is provided at the after end. On either side of the bandstand

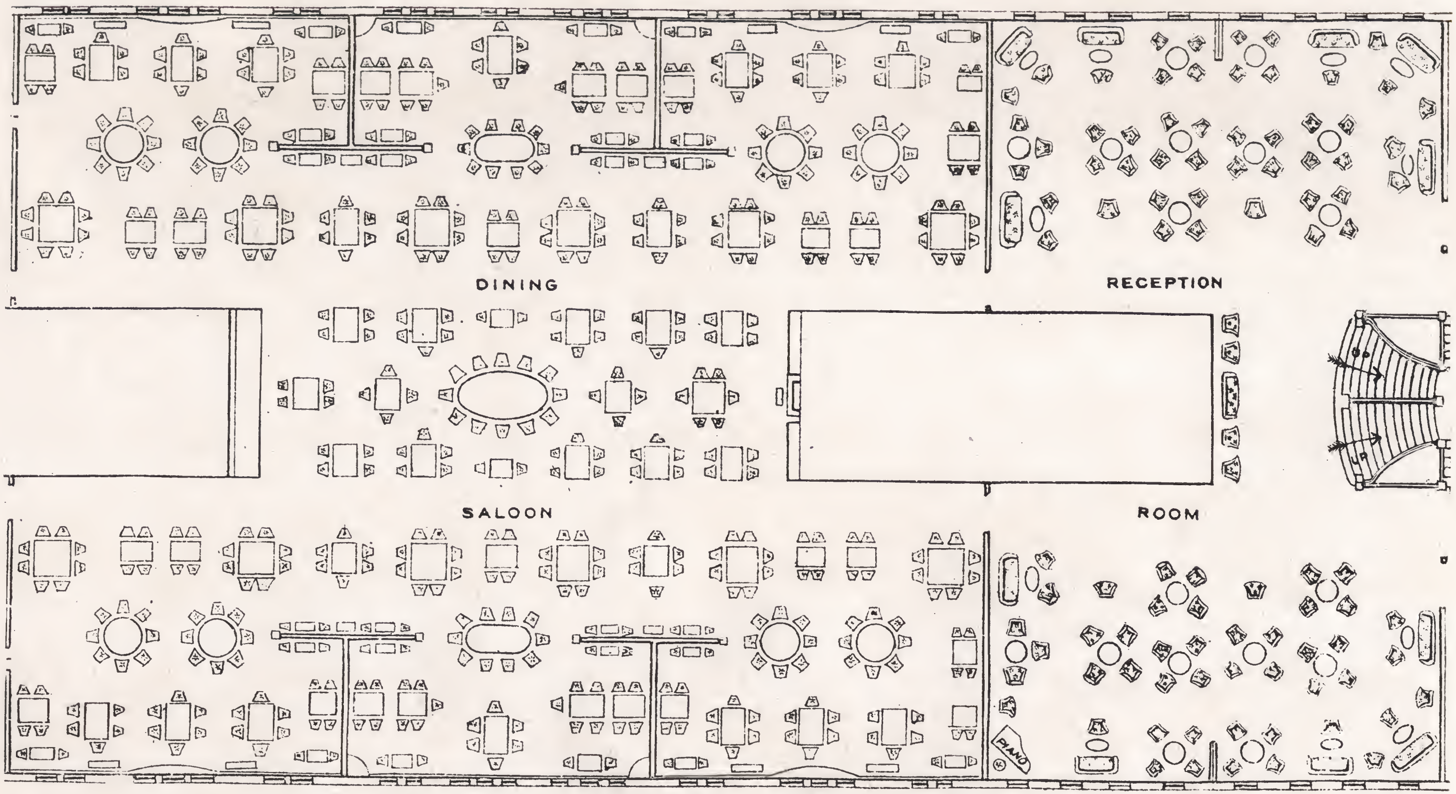


Fig. 76.—Plan of First=class Dining Saloon and Reception Room on C_Deck.

Fig. 77.—First-class Reception Room.

The First-class Dining Saloon of the White Star Liner "Olympic."

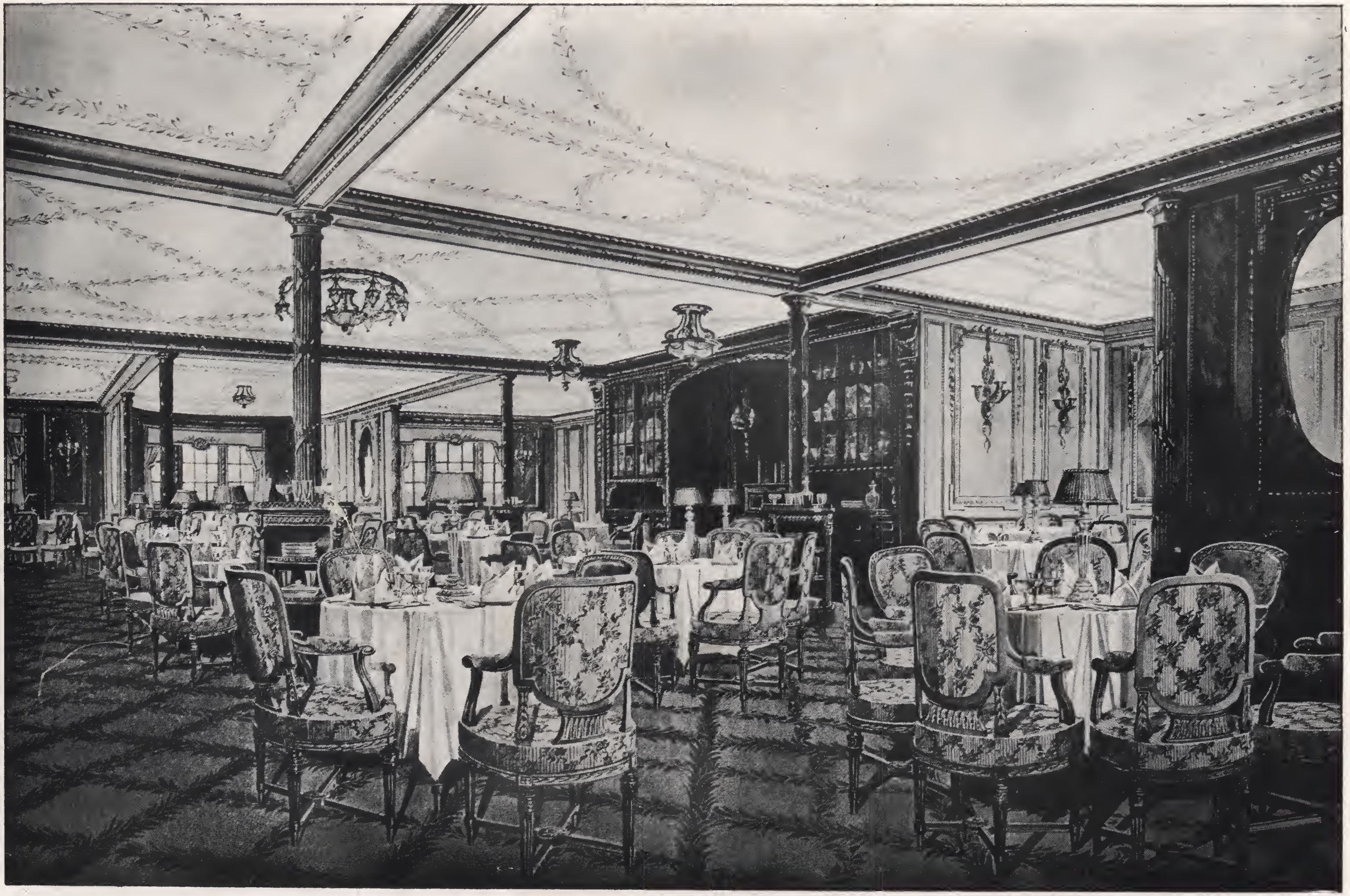


Fig. 78.—First-class Restaurant.

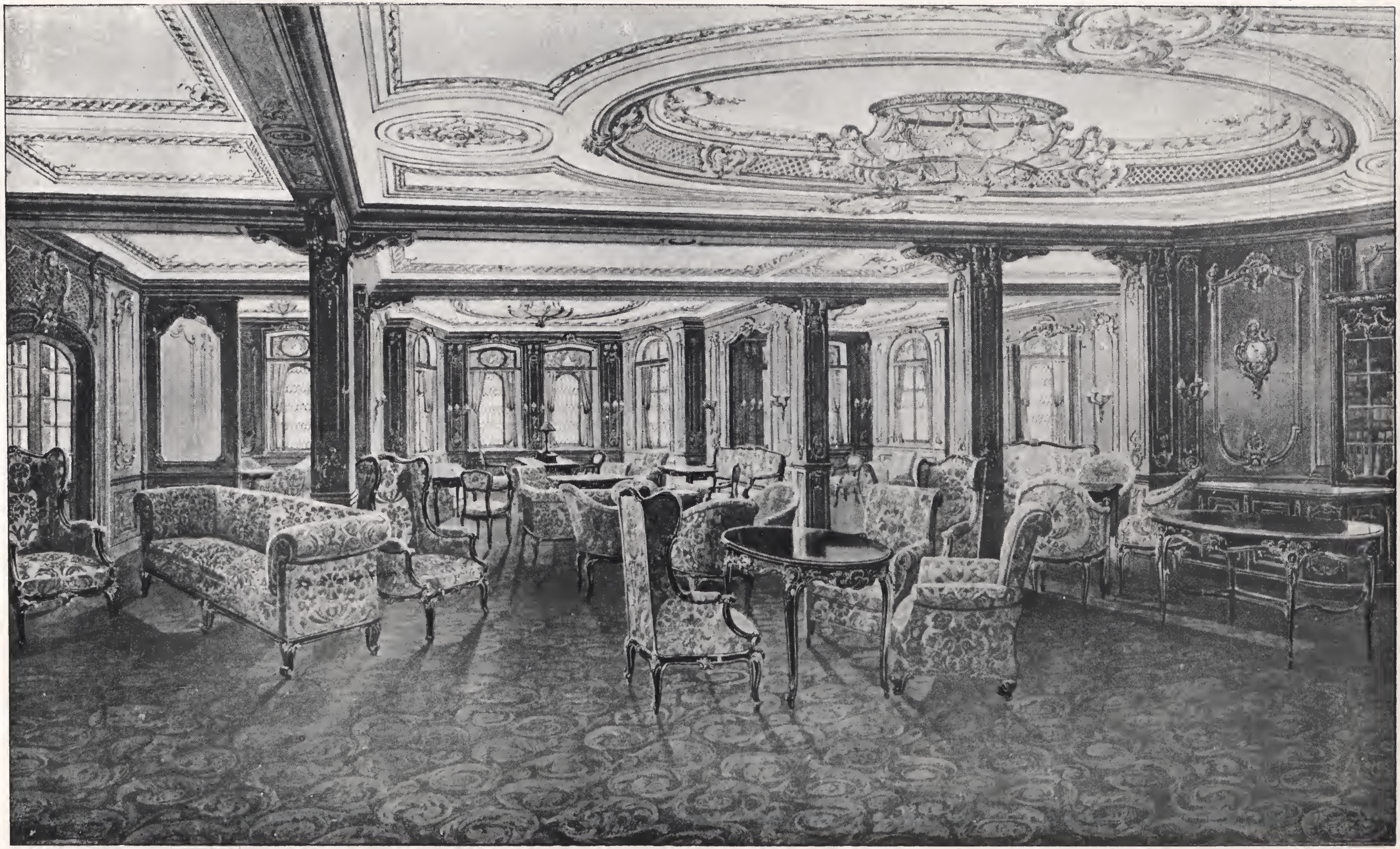


Fig 79.—First-class Lounge.

is a carved buffet, the lower portion of which is used for cutlery and the upper portion for the silver service, thus completing the necessities for a well-appointed restaurant to satisfy every requirement.

Lounge.

THE first-class lounge (Fig. 79) is situated upon the promenade deck A, and is a noble apartment in the Louis Quinze style, the details being taken from the Palace at Versailles. Here passengers will indulge in reading, conversation, cards, tea-drinking, and other social intercourse. The room is furnished as shown in Fig. 80, and has a length of 59ft., a breadth of 63ft., and a height of no less than 12ft. 3in. The walls are covered with finely carved *boiseries* in which, without interfering with the symmetry of the whole, the fancy of the carver has shown itself in ever-varying detail. At one end is a large fireplace, and at the other a bookcase from which books can be borrowed.

Reading and Writing Room.

ADJACENT to the lounge is the reading and writing room (Fig. 81), which is in the late Georgian style of about 1770-80 A.D. The panelling is finished in white, as is also the ceiling. The room is 41ft. long, 41ft. wide, and, like the lounge, is 12ft. 3in. high, the furniture being arranged as shown in Fig. 80. On one side is the great bow window clearly shown in Fig. 81, from which an uninterrupted view of the horizon will be obtained. At the forward end is a large recess, slightly raised above the general level, which produces a most pleasing effect in the appearance of the room. The pure white walls and the light and elegant furniture will make this essentially a ladies' room.

Smoking Room.

THE smoking room (Fig. 82) is situated towards the after end of the promenade deck A, and is entered from the after main entrance. It is without doubt the finest apartment of its kind on the ocean. The length is 65ft., breadth 63ft., and height 12ft. 3in. The style is a free adaptation of early Georgian of about 1720 A.D., and is based upon the decorations pertaining in various old English houses of that period. The walls are panelled with the finest mahogany, but the characteristic carving of the Georgian style has been largely replaced by inlaid work in mother-of-pearl. The arrangement of the furniture is shown in Fig. 83. A large open fireplace is situated at the after end of the room, over which is placed a fine painting, the work of Mr. Norman Wilkinson, entitled "The Approach of the New World." Light enters the room, tempered and softened, through large painted windows of remarkable size and beauty (see Fig. 84), upon which are depicted landscapes, ancient ships, and other subjects.

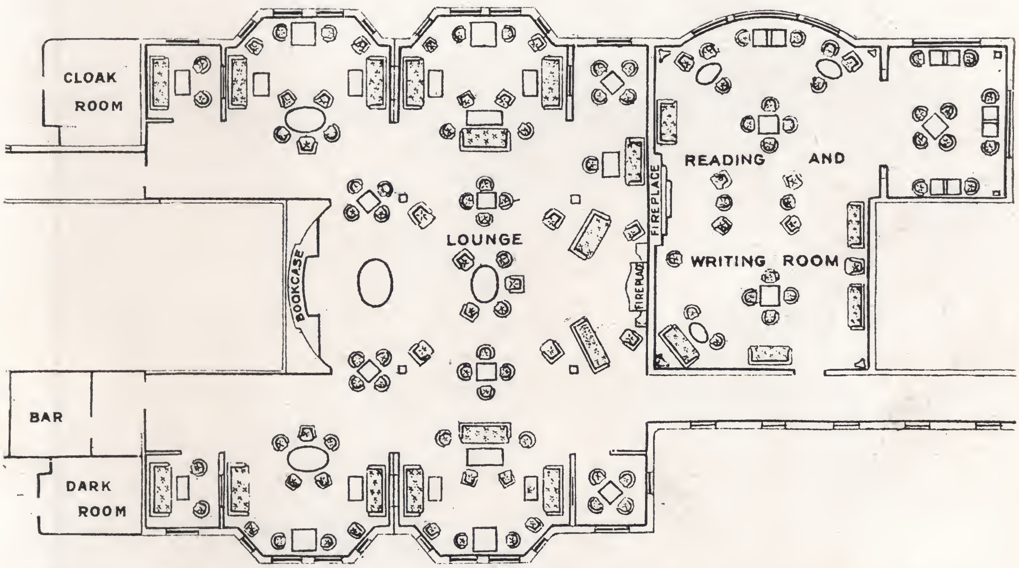


Fig. 80.—Plan of First-class Lounge and Reading and Writing Room on A Deck.

Verandah Cafes and Palm Courts.

A VERANDAH and palm court (Fig. 85) is situated on each side of the deck house immediately abaft the smoking room, with an entrance from the latter on the

Fig. 81.—First-class Reading and Writing Room.

Fig. 82.—First=class Smoking Room.

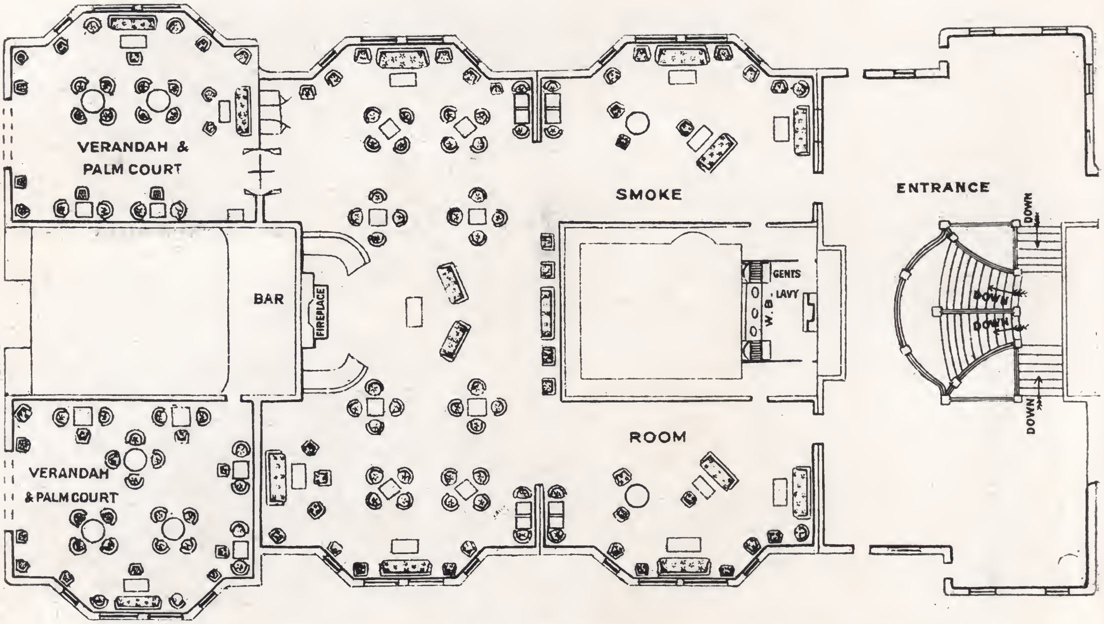


Fig. 83.—Plan of First=class Smoking Room, Verandahs, and Palm Courts.

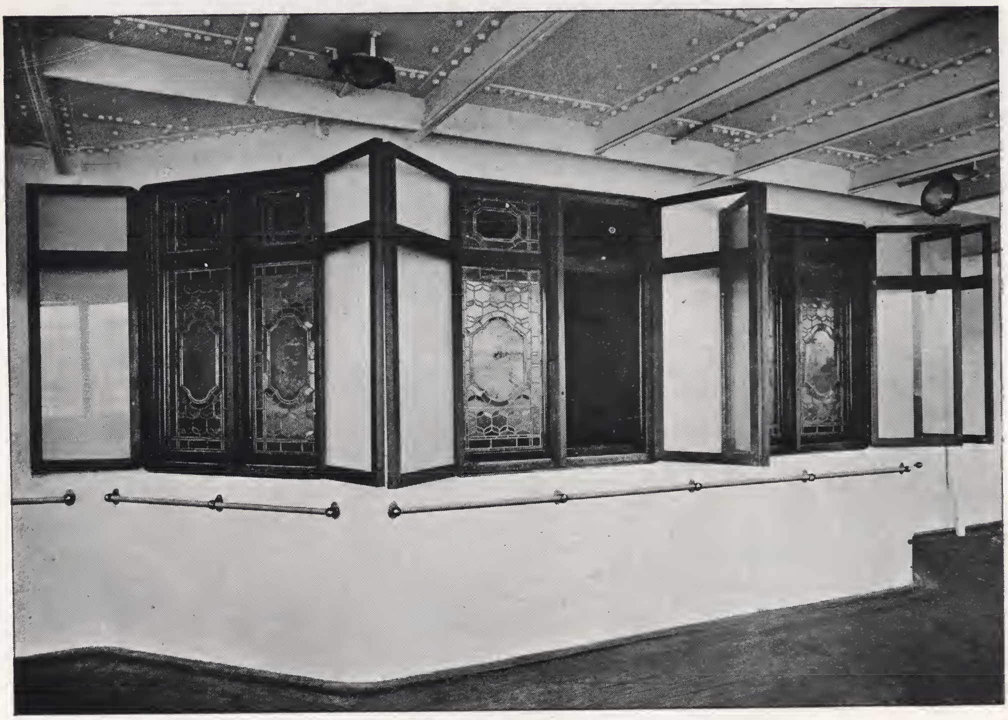


Fig. 84.—Windows of First=class Smoking Room.

Fig. 85.—One of the Verandahs and Palm Courts.

Fig. 86.—Corner in one of the Verandahs.

port side only by a revolving draught-proof door. Each compartment is 30ft. long by 25ft. wide. From the plan view of Fig. 83 it will be seen that the verandahs are completely enclosed on all sides with the exception of the openings provided in the after end for access from the promenade space. With this arrangement the cafés are less liable to draughts and the effects of inclement weather than is the case with the wide open-ended cafés adopted in other vessels. To maintain the impression of sitting in the open, windows of exceptional size have been provided, as will be seen from the illustration Fig. 85. The style is *Treillage* of Louis Seize period; and to create the illusion that the cafés are on shore, ivy and climbing plants are trained up the green trellis-work panels; see Fig. 86. The furnishings consist of numerous little tables, comfortable cane settees, and armchairs of elegant design.

Turkish Baths.

THE Turkish baths are situated on the middle deck F, conveniently adjoining the main companion-way. They include the usual steam, hot, temperate, shampooing, and cooling rooms. There are also modern electric baths, of which a description will be found in the chapter dealing with the electrical equipment. The cooling room (Fig. 87) is in many respects one of the most interesting and striking rooms in the ship, and is appropriately decorated in the Arabian style of the seventeenth

Fig 87.—Cooling Room of the Turkish Baths.

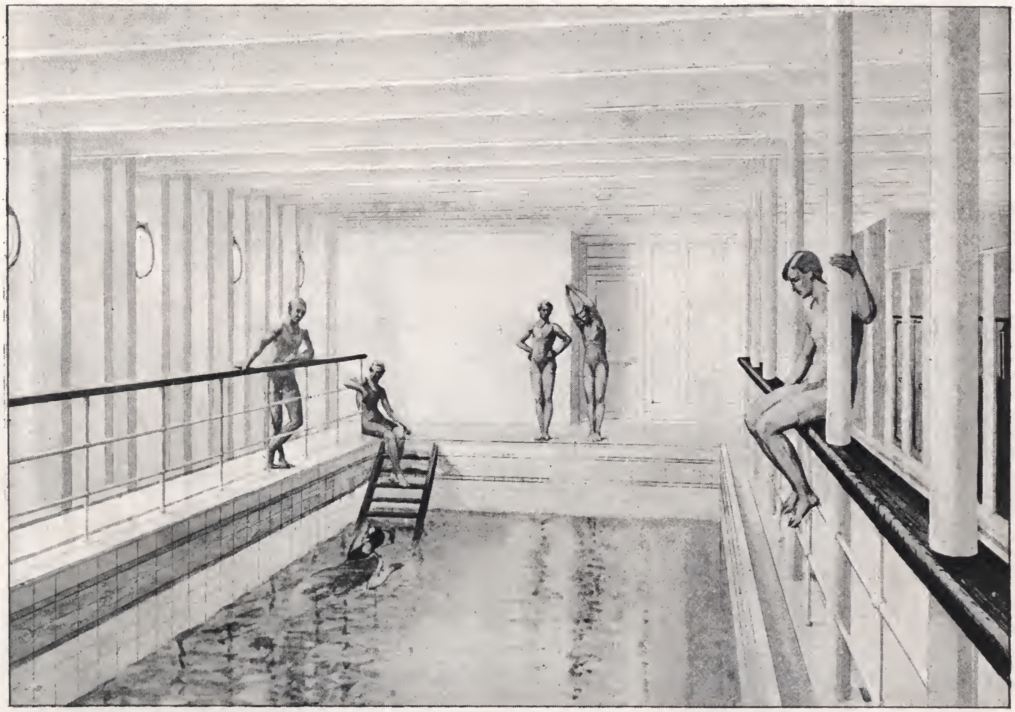


Fig. 88.—Swimming Bath.

Fig. 89.—Squash Racquet Court.

century. The portholes are concealed by an elaborately carved Cairo curtain, through which the light fitfully reveals something of the grandeur of the mysterious East. The walls from the dado to the cornice are completely tiled in large panels of blue and green, surrounded by a broad band of tiles in a bolder and deeper hue. The ceiling cornice and beams are gilt, with the intervening panels picked out in dull red. From the panels are suspended bronze Arab lamps. A warm coloured teak has been adopted for the dado, doors, and panelling, and forms a perfect setting to the gorgeous effect of the tiles and ceiling. The stanchions, also cased in teak, are carved all over with an intricate Moorish pattern, surmounted by a carved cap. Over the doors are small gilt domes, semi-circular in plan, with their soffits carved in a low-relief geometrical pattern. Low couches are placed around the walls with an inlaid Damascus table between each, upon which coffee and cigarettes or books may be placed. On one side is a handsome marble drinking fountain, set in a frame of tiles. A teak dressing table and mirror, with all its accessories, and a locker for valuables are also provided, while placed around the room are a number of canvas chairs.

Swimming Bath.

THE swimming bath (Fig. 88) is situated on the starboard side of deck F, immediately forward of the Turkish baths. It is 30ft. long by 14ft. wide, and is fitted out exactly as would be an up-to-date swimming bath on shore.

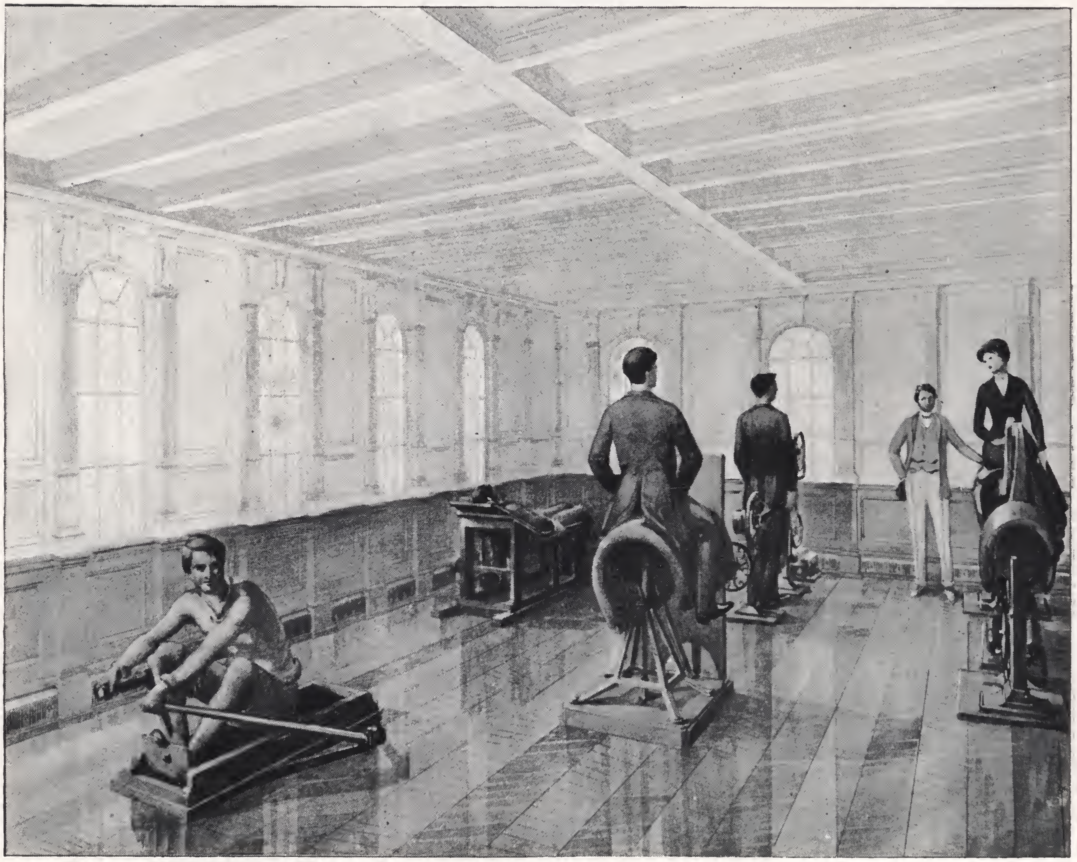


Fig. 90.—Gymnasium.

Squash Racket Court.

THE squash racket court (Fig. 89) is another innovation which should prove popular with those disposed to athletic exercise. It is situated on the lower deck at the centre of the ship, just forward of the foremost boiler room, and extends two decks high for a length of 30ft. and a width of 20ft. A gallery for spectators is placed at the after end of the court, at the middle deck level.

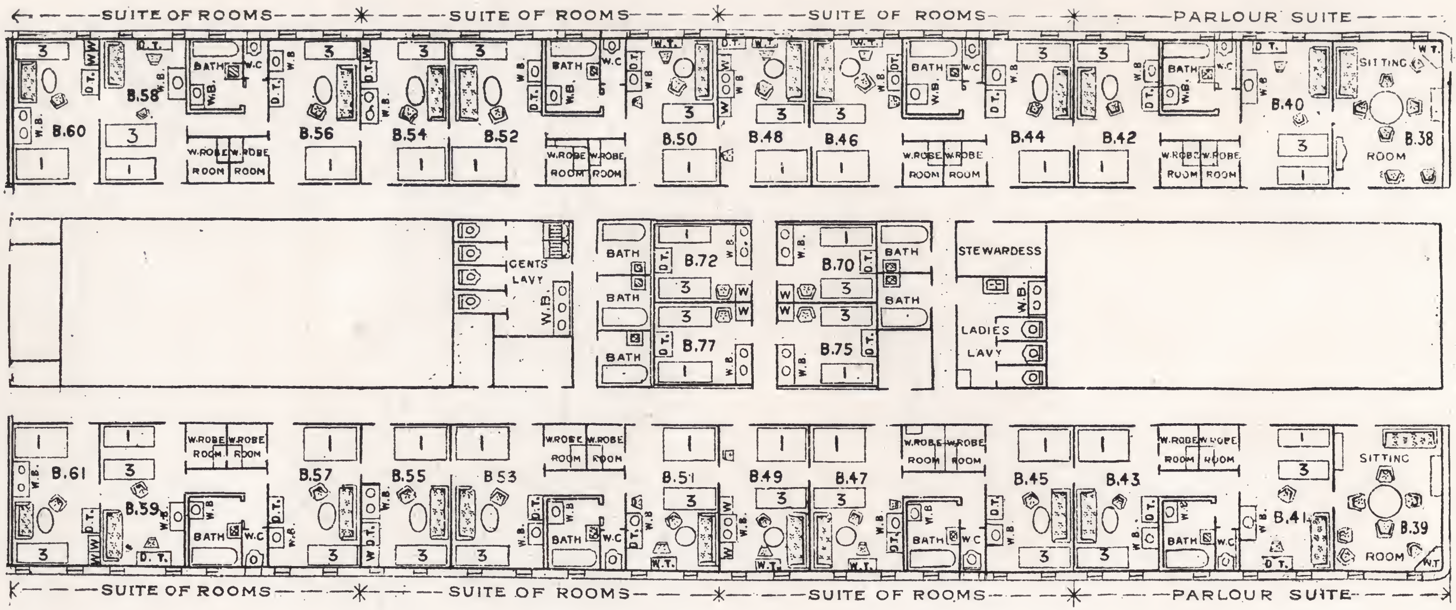


Fig. 91.—Plan of Suite Rooms on B Deck.

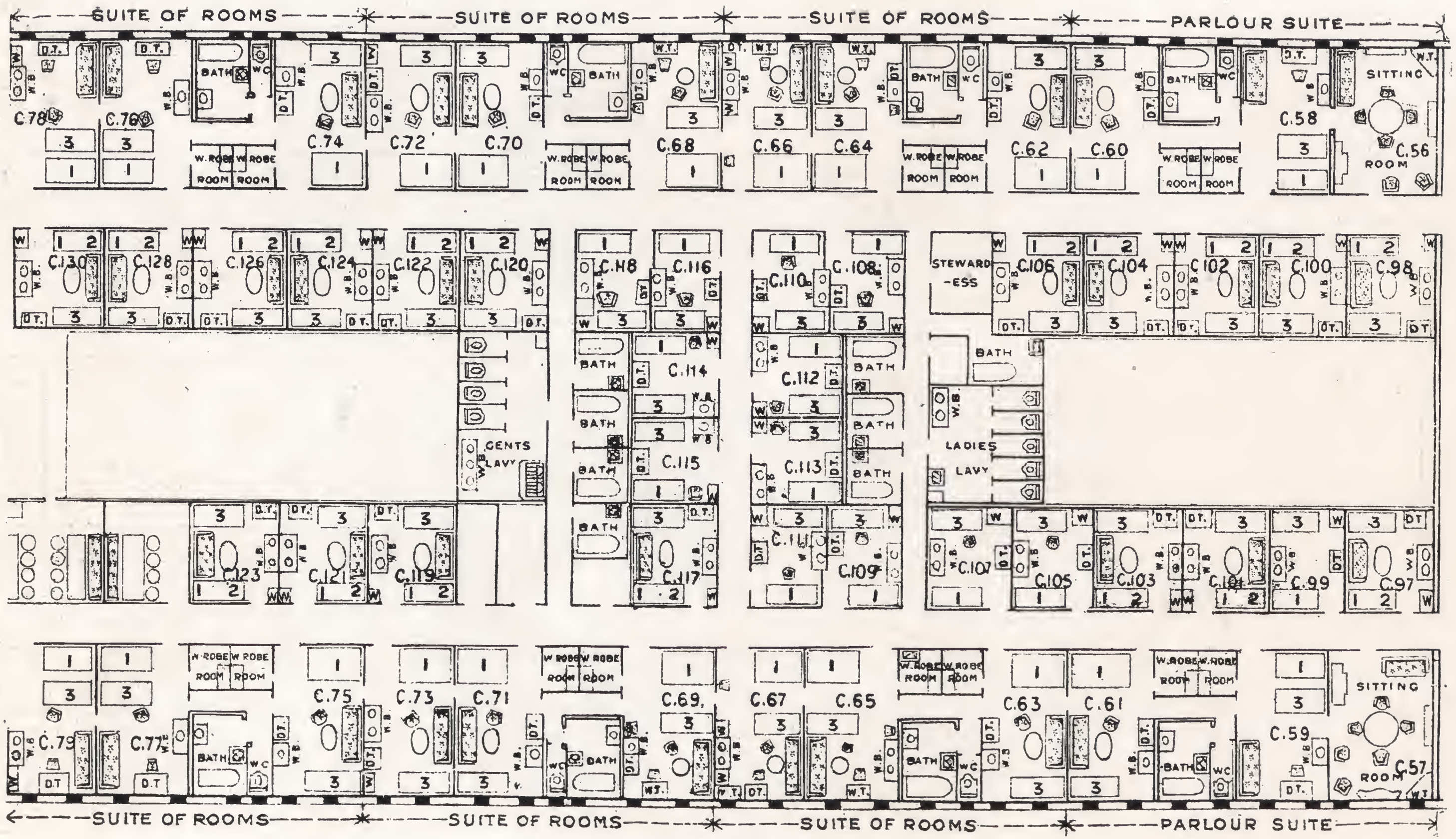


Fig. 92.—Plan of Suite Rooms on C Deck.

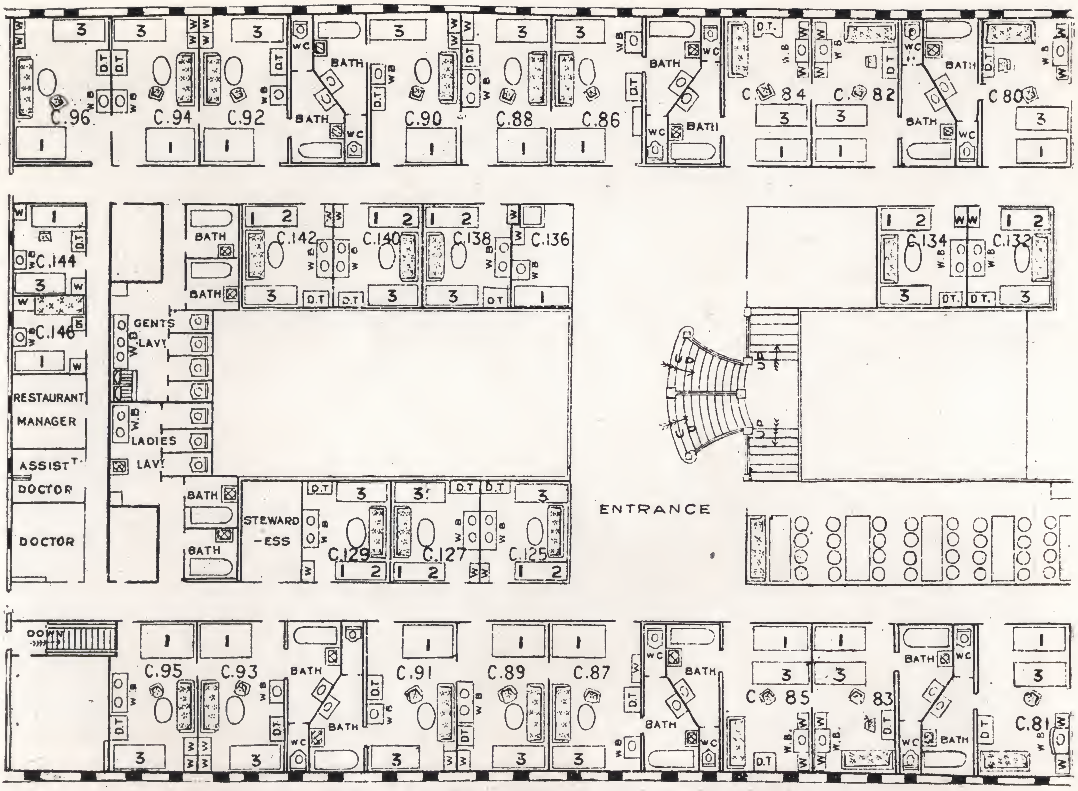


Fig. 93.—Plan of Typical Special Staterooms on C Deck.

Fig. 94.—Sitting Room of Parlour Suite.

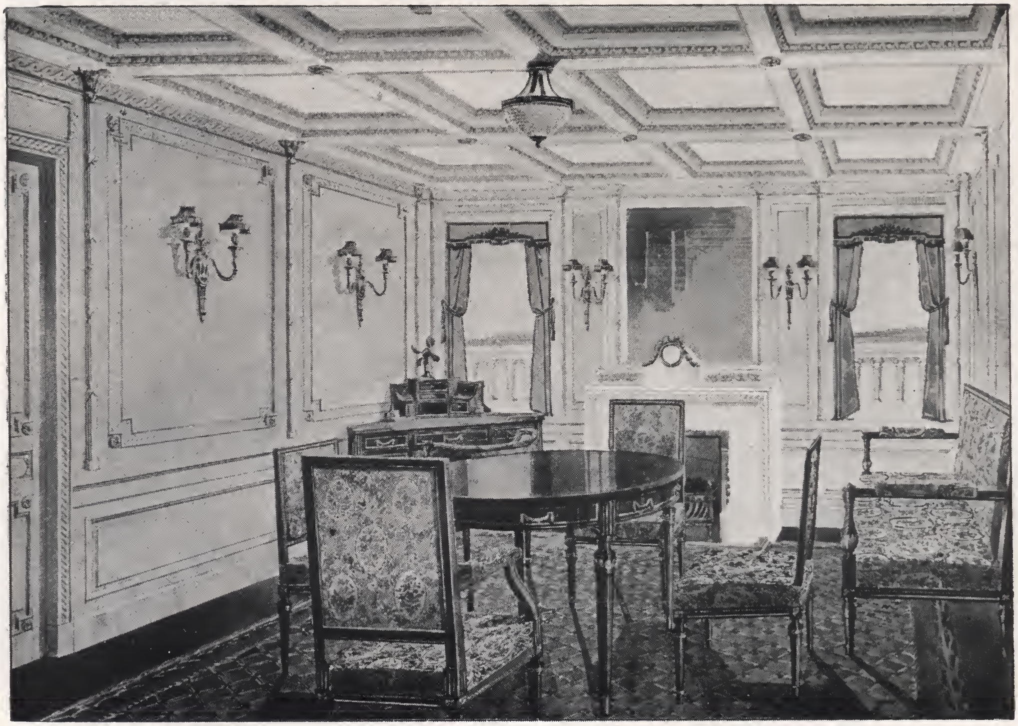


Fig. 95.—Sitting Room of Parlour Suite, Room B 38. (Style, Louis Seize.)

Fig. 96.—Sitting Room of Parlour Suite, Room C 56. (Style, Louis Quatorze.)

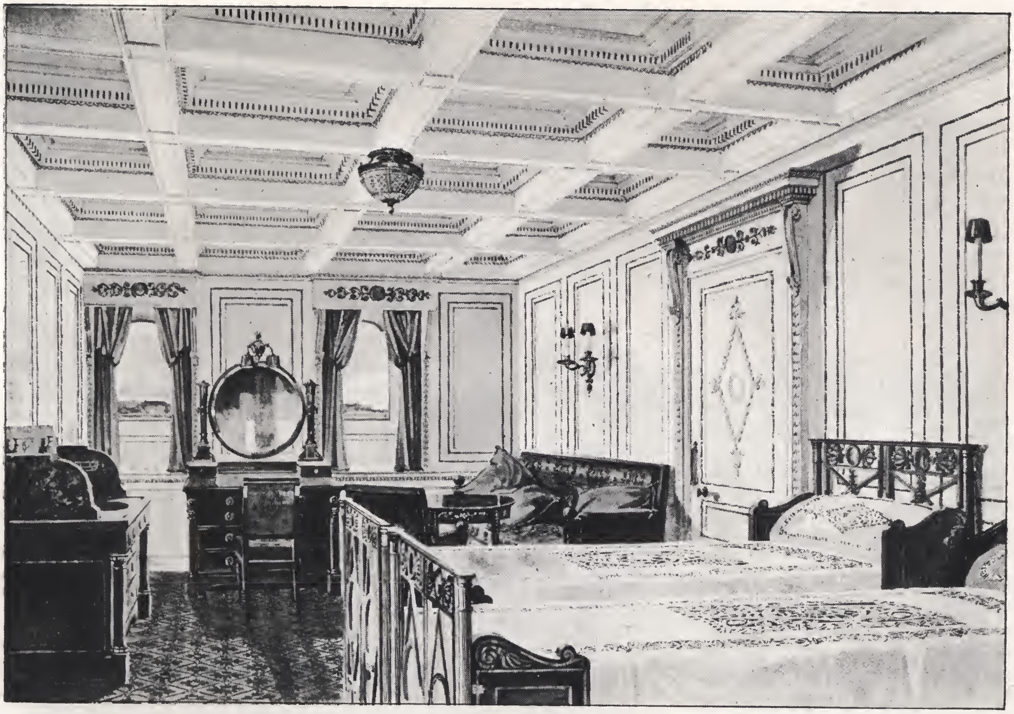


Fig. 97.—**Bedroom of Parlour Suite, Room B 40.** (Style, Empire.)

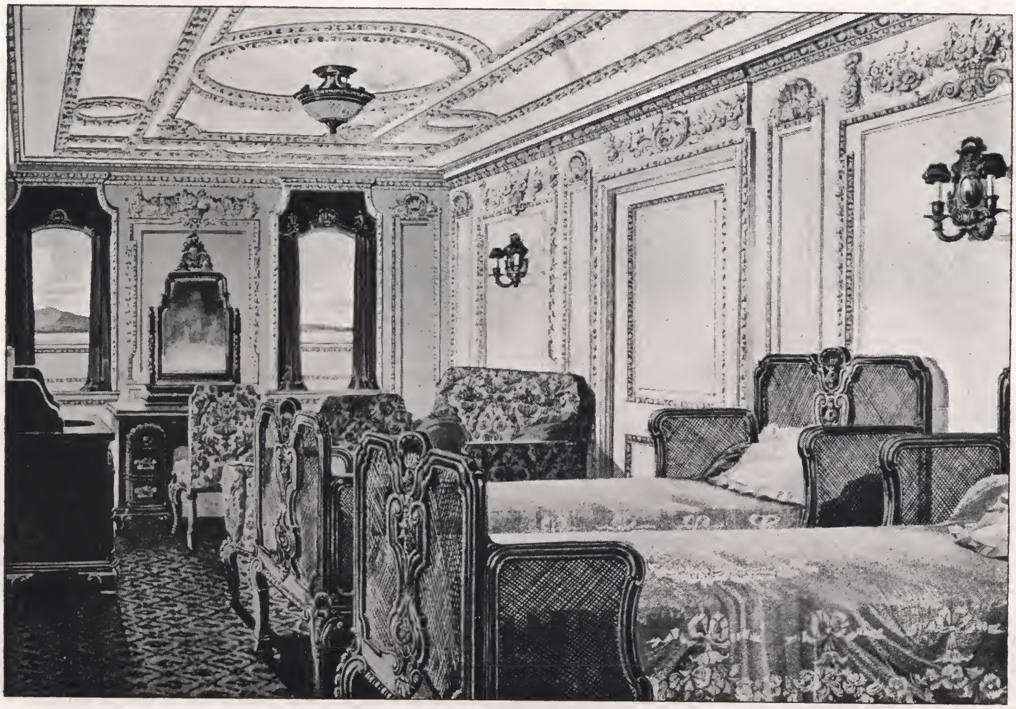


Fig. 98.—**Suite Bedroom, B 59.** (Style, Georgian.)

Gymnasium.

The gymnasium (Fig. 90) is situated on the boat deck, immediately abaft the forward grand entrance, and is provided with all the latest appliances. It is 44ft. long, by 18ft. wide, by 9ft. 6in. high, and is lighted by eight windows of exceptional size. Here passengers can indulge in the action of horse-riding, cycling, boat-rowing, etc., and obtain beneficial exercise, besides endless amusement. The gymnastic appliances have been supplied by Messrs. Rossel, Schwarz and Co., of Wiesbaden.

91 and 92. Each parlour suite consists of one sitting room, two bedrooms, two wardrobe rooms, and a private bath and lavatory. Three of the sitting rooms are illustrated by Figs. 94, 95 and 96. In the case of the sitting room of No. 1 suite, illustrated by Fig. 95, the style is Louis Seize, and in No. 3 suite, illustrated by Fig. 96, the style is Louis Quatorze. A typical bedroom of the parlour suites is illustrated by Fig. 97, which shows the bedroom of No. 1 suite adjoining the sitting room, the style in this case being Empire.

Fig. 99.—*Suite Bedroom, C 63.*

En Suite and Special Staterooms.

The special staterooms, which are situated on B and C decks amidships between the two grand staircases (see Plate IV. and Figs. 91, 92 and 93) have been fitted out with unparalleled luxury. The different styles and periods adopted for the internal decoration of the various rooms include Louis Seize, Empire, Adams, Italian Renaissance, Louis Quinze, Louis Quatorze, Georgian, Regence, Queen Anne, Modern Dutch, and Old Dutch. The most expensive accommodation is provided by parlour suites, of which there are four, adjoining the forward grand entrance, one on each side of the ship on B and C decks respectively ; see Figs.

Aft of the parlour suites on B and C decks are twelve suites of rooms, six on each deck. Each suite consists of three combined bed and sitting rooms with intercommunication doors, two wardrobe rooms, and a private bath and lavatory. The rooms can, of course, be let separately if occasion arises for doing so. Typical suite rooms are shown in Figs. 98, 99, and 101. In addition to the suite rooms just mentioned, there are on B and C decks sixteen rooms of equal size and magnificence, each with a private bathroom and lavatory, and nine such rooms without special bathrooms unless let in conjunction with an adjoining room. Examples of these rooms are illustrated by Figs. 100, 102, 103, and 104.

The *en suite* and special rooms are about 11ft. long, by 18ft. wide, and are limited to two occupants. The furnishings, as will be seen from Figs. 91, 92, and 93, consist of two bedsteads, a dressing table, wash basin, sofa, table, easy chair, a wardrobe in those cases where no separate wardrobe room is provided, and in some cases a writing table and additional chair. A number of the bedsteads are 4ft. wide. The rooms on B deck have two large sliding windows in the deckhouse side. On C deck, as the rooms adjoin the shell of the ship, two large oblong sidelights, 22in. by 17in., are fitted to each.

Fig. 100.—Special First-class Stateroom, B 63.

First-class Staterooms.

As will be seen from Plates III. and IV. and the typical plans of cabins shown in Figs. 105 and 106, every variety of first-class stateroom has been provided. A special feature is the large number of single-berth rooms, of which there are no less than 96, mainly situated on A and B decks forward of the grand entrance. A typical single-berth room on A deck is shown in Fig. 107, and on B deck in Fig. 108. In all the single-berth rooms, bedsteads are provided instead of the usual fixed berths, and there is also a large sofa, wardrobe, dressing table, and wash basin. The remaining staterooms are mostly arranged for three passengers, and are provided with two bedsteads and a hinged Pullman upper berth. The Pullman berth is clearly shown in Fig. 109, which shows a typical three-berth room on C deck. Other three-berth rooms on C deck are illustrated by Figs. 110 and 111. It will be seen from the plans that the staterooms on B, C, D and E decks are arranged on the tandem principle, whereby the inner tier of cabins receive natural light from windows or sidelights in the side of the deckhouse or ship respectively. The staterooms on A deck are, of course, lighted from above. In no case are more than three passengers accommodated in one room. Ten of the three-berth rooms on C deck forward have their own private bathrooms (see Fig. 106), and intercommunication doors are provided so that two rooms may be let together if required.

Second-class Accommodation.

The second-class accommodation is mainly placed aft, and extends over no less than seven decks. It would have been difficult a few years ago to conceive such sumptuous apartments as have been provided on the

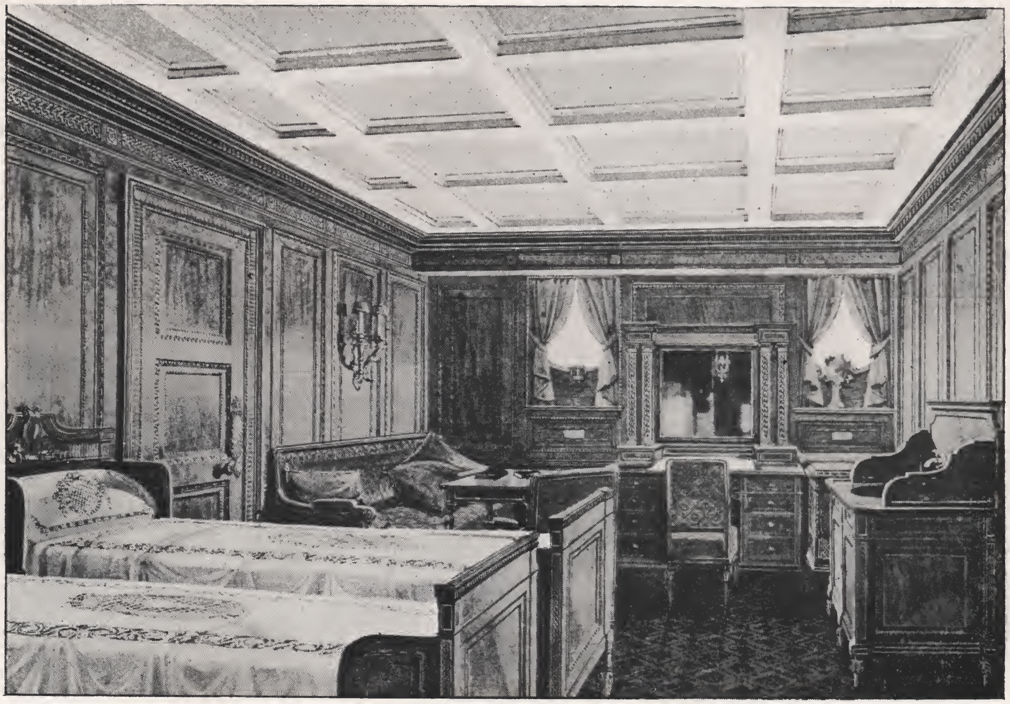


Fig. 101.—Suite Bedroom, C 76. (Style, Italian Renaissance.)

Fig. 102.—Special Stateroom, C 84. (Style, Adams.)

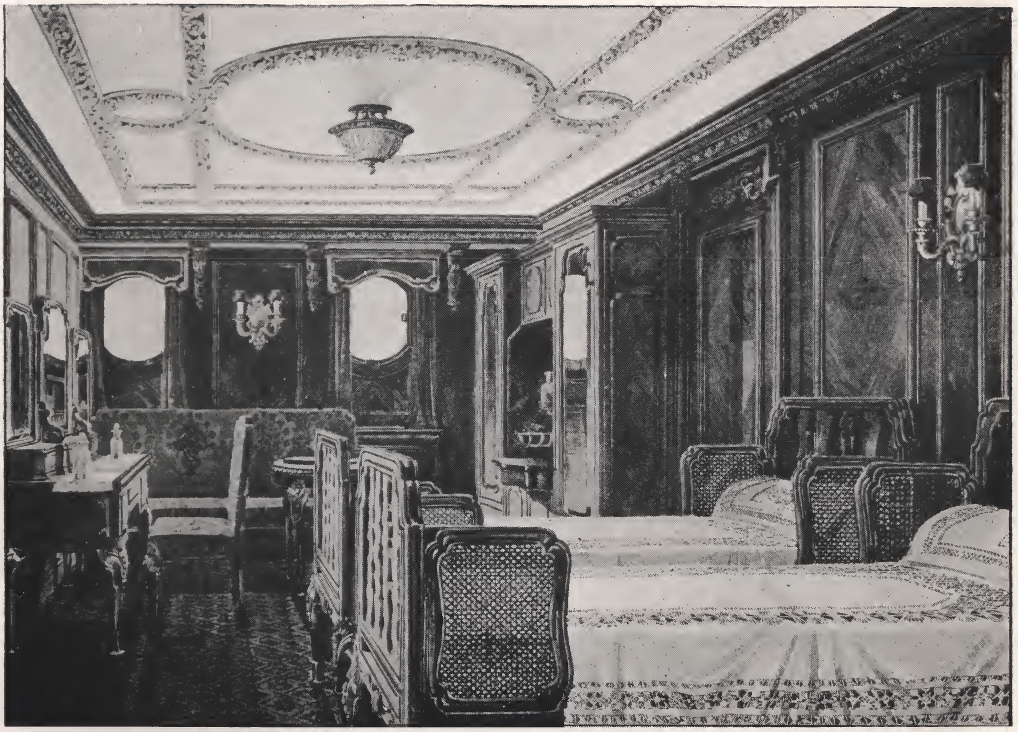


Fig. 103.—**Special Stateroom, C 80.** (Style, Georgian.)

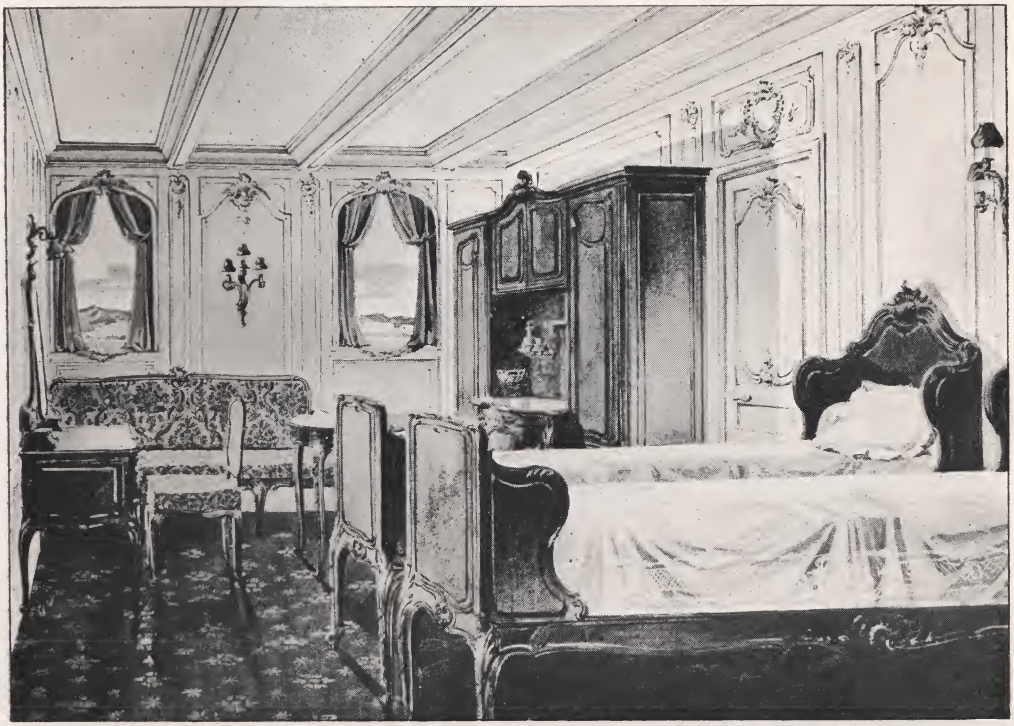


Fig. 104.—**Special Stateroom, B. 64.** (Style, Louis Quinze.)

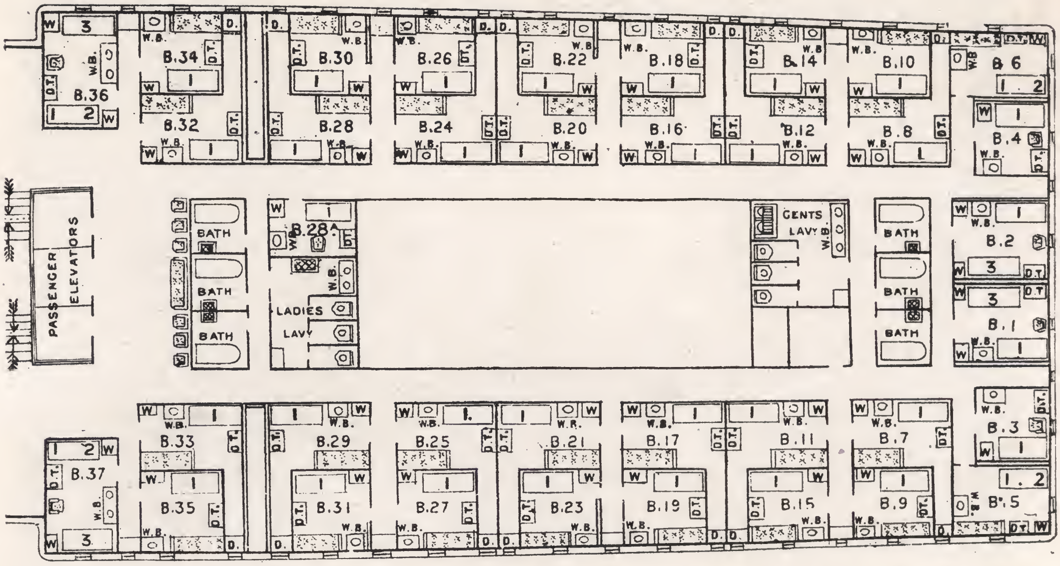


Fig. 105.—Plan of Staterooms on B Deck, forward of Grand Entrance.

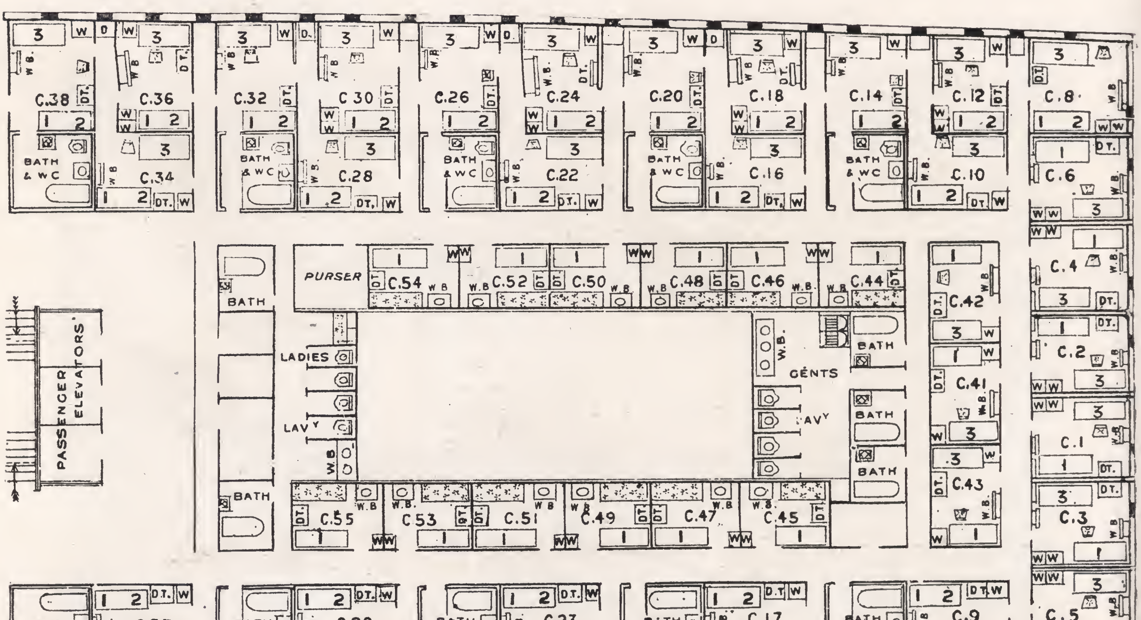


Fig. 106.—Plan of Staterooms on C Deck, forward of Grand Entrance.

Olympic and *Titanic*. Access from one deck to another is obtained by means of the grand staircase and also by an electric elevator, which is an innovation. The public rooms include a large dining saloon, smoking room and library. Indeed, as in the case of the first-class, everything has been done to make the accommodation superior to anything previously seen afloat.

Fig. 107.—First-class Single-berth Stateroom on A Deck.

Second-class Grand Entrances and Staircases.

THE second-class forward grand entrances and staircase (Fig. 112) are handsomely panelled in oak. This staircase is one of the features of the ship, as it extends through seven decks and has an electric elevator incorporated in the centre which serves six decks. The after staircase, with its entrance halls, is also panelled in oak and extends through five decks.

Second-class Dining Saloon.

THE second-class dining saloon (Fig. 113) is situated on the saloon deck just abaft the kitchens. It is 71ft. long and extends the full width of the ship. The style of decoration adopted is early English, carried out

Fig. 108.—First-class Single-berth Stateroom on B Deck.

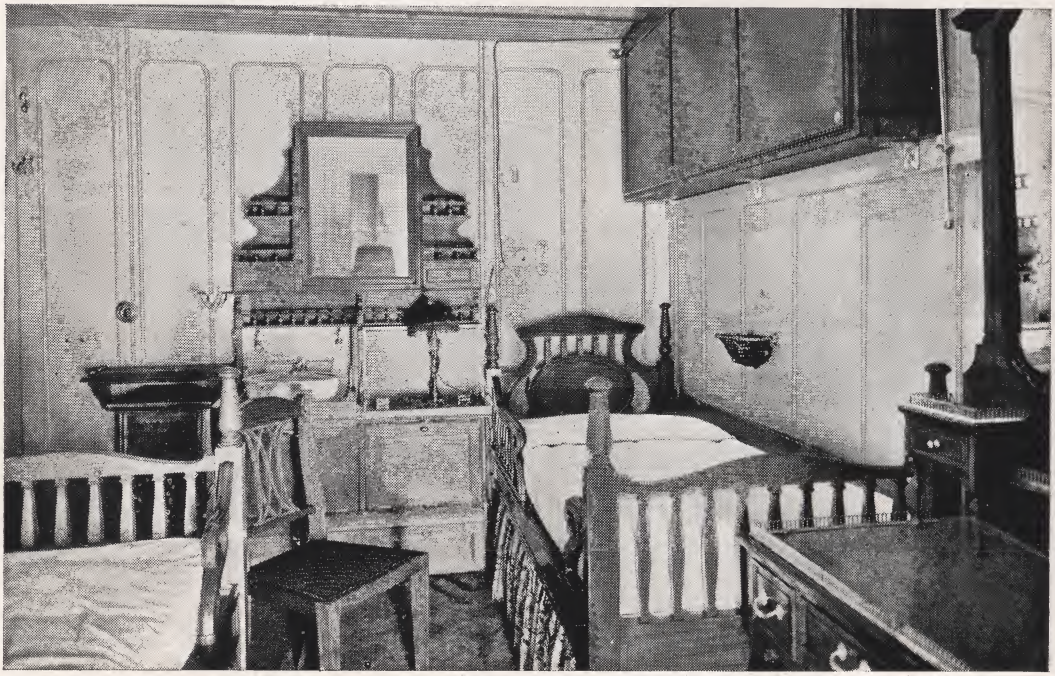


Fig. 109.—First-class Three-berth Stateroom on C Deck. (C 9 and similar.)

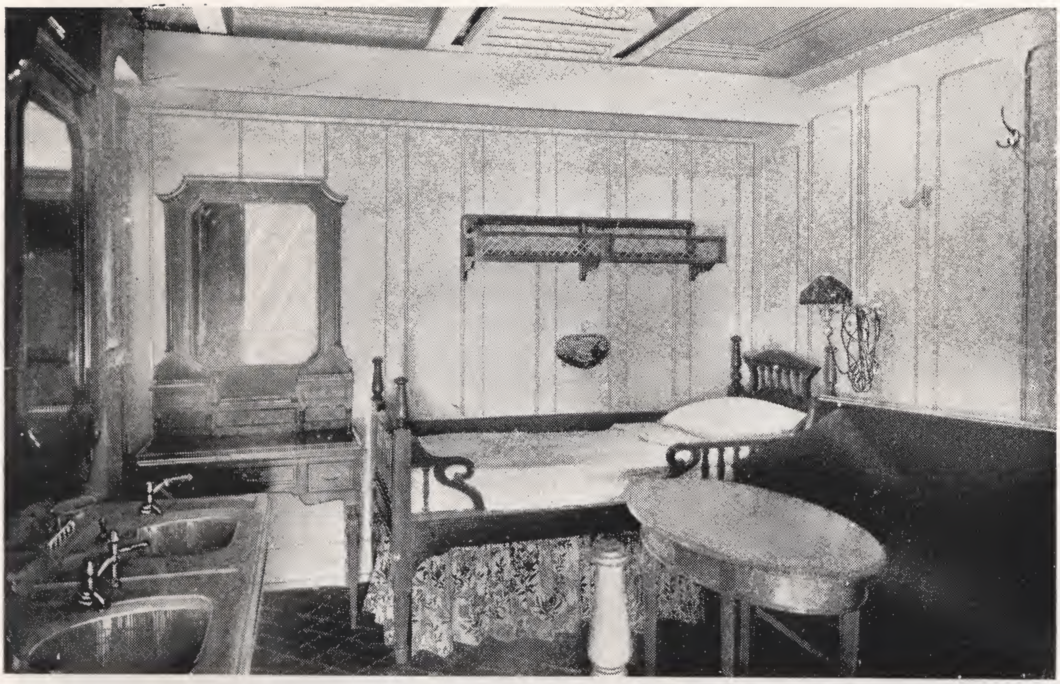


Fig. 110.—First-class Three-berth Stateroom on C Deck. (C 117 and similar.)

Fig. 111.—First-class Three-berth Stateroom on C Deck. (C 15 and similar.)

in oak. The panelling is most tasteful in design, as will be seen from Fig. 114. The furniture consists in this case of long tables and revolving chairs, seating accommodation being provided for 394 people. As in the case of the first-class saloon, efficient service of food is ensured by the proximity of the saloon to the kitchens, and the large serving pantry adjoining the forward end.

Second-class Library.

The second-class library (Fig. 115) is another beautiful apartment, the style in this case being Colonial Adams. It is 40ft. long, by 58ft. wide, and is situated on the shelter deck aft, between the two second-class stairways. The panelling is in sycamore, handsomely relieved with carvings, and the dado is in mahogany. The furniture, which is of special design, is also of mahogany, and is covered with tapestry. A large bookcase is provided at the forward end. The side windows are of large size, draped with silk curtains and arranged in pairs, as shown in Fig. 116, which also well illustrates the beautiful panelling. A handsome Wilton carpet completes the fine effect produced.

Second-class Smoking Room.

The second-class smoking room (Fig. 119) is situated on the promenade deck B, immediately above the library, and is 36ft. long by 62ft. wide. In this case the decoration is a variation of the Louis Seize period. The panelling and dado are of oak, relieved with carving. The furniture is of oak, upholstered with plain dark green morocco leather. The floor is laid with linoleum tiles of special design.

Fig. 112.—Second-class Grand Staircase and Entrance Hall.

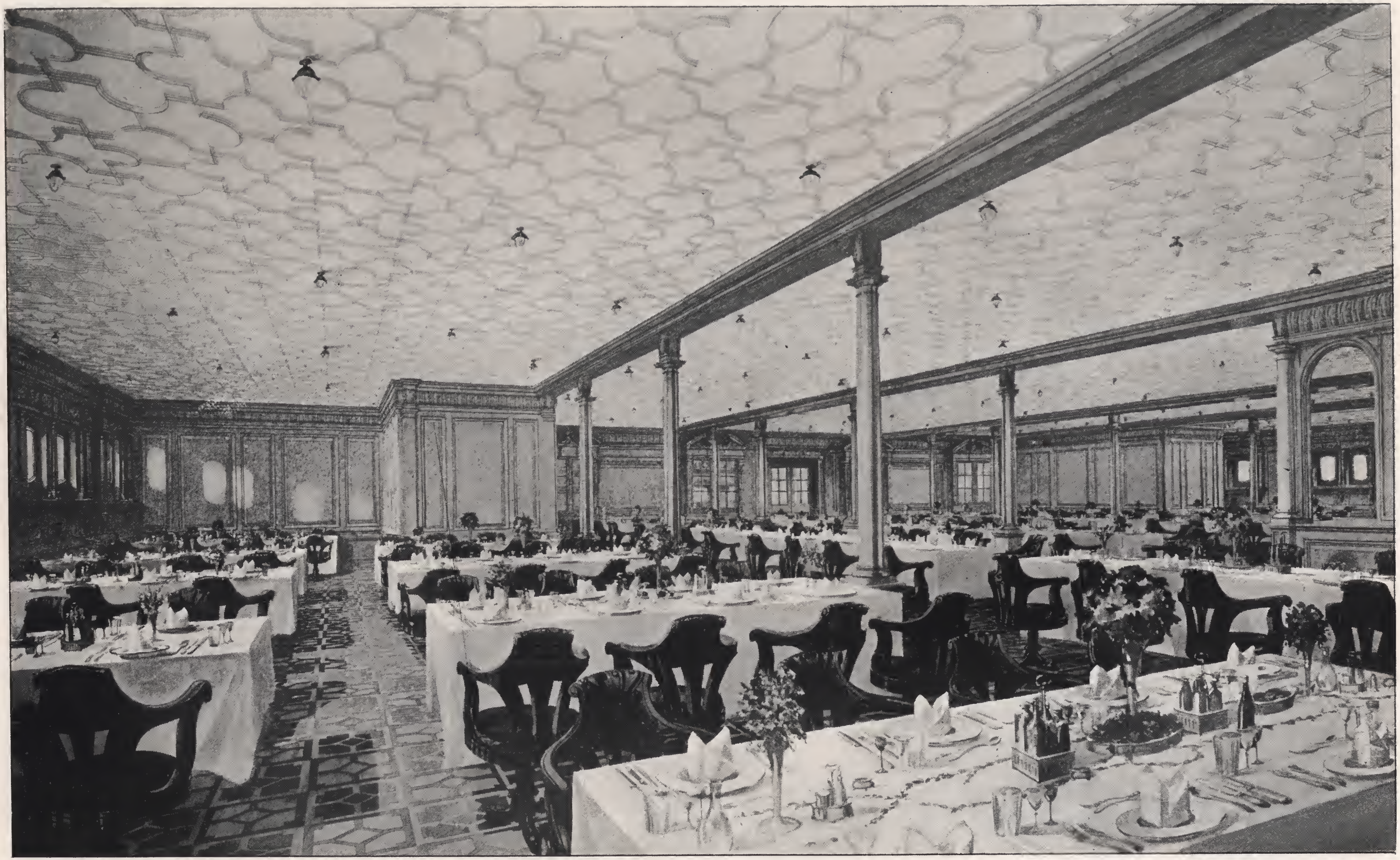


Fig. 113.—Second-class Dining Saloon.

Second-class Staterooms.

The second-class staterooms are situated aft, on decks D, F, and G, but on E deck the cabins extend well towards amidships on the starboard side, as will be seen from Plate IV. They are hardly inferior to the first-class ordinary staterooms, except that four passengers are accommodated in one room instead of three. As in the first-class, most of the cabins are arranged on the tandem principle, which ensures natural light to each cabin. The rooms are finished in white enamel, and have mahogany furniture covered with moquette. The floor covering consists of linoleum tiles.

Fig. 114.—Panelling in Second-class Dining Saloon.

Third-class Accommodation.

The accommodation for third-class passengers is of a very superior character. The public rooms are large, airy apartments, suitably furnished and in excellent positions, and the same may be said with regard to the third-class staterooms and berths. Third-class passengers to-day have greater comforts provided than had first-class passengers before the great modern developments in passenger-carrying, for which the White Star Line has been largely responsible.

Third-class Dining Saloon.

The third-class dining saloon is situated amidships on the middle deck F. It consists of two compartments extending from side to side of the ship for a length of 100ft., with seating accommodation for 473 passengers. The chairs are of special design, as will be seen from Fig. 118, which shows a portion of the saloon. The room is well lighted by sidelights and is finished in white enamel. Adjoining the after end are the third-class galley and pantries.

Third-class General Room.

The third-class general room is situated aft, inside the poop on the starboard side, and has a length of 36ft. and width of 38ft. It is panelled and framed in pine and finished in white enamel. The furniture is of teak, and includes a number of settees, chairs, and tables, as shown in Fig. 119.

Third-class Smoking Room.

The third-class smoking room occupies a corresponding position to the general room, on the port side of the ship, and is of exactly the same size. It is panelled and framed in oak, and is a very suitable and comfortable room. The furniture is of teak and similar to that in the general room.

Third-class Staterooms.

The third-class staterooms are placed on E, F, and G decks forward, and on D, E, F, and G decks aft. They are mostly arranged for two and four passengers; but in some rooms six, eight, or ten people can be accommodated. The provision of such a large number of two-berth rooms is an innovation, and should be very popular with this class of passenger. In addition to the staterooms, accommodation is provided for 164 people in open berths on G deck forward.

Beds.

As already mentioned when describing the first-class staterooms, all the lower berths consist of cot beds in brass, mahogany, and oak, many of them being 4ft. wide. The brass cot beds, which have been supplied by Messrs. Hoskins and Sewell, Limited, of Birmingham, for both the *Olympic* and *Titanic*, are all lacquered by that firm's "Varnoid" process, which gives a lustre and finish to the brass work unequalled by any other lacquer, and is guaranteed to stand the action of the sea air and sea water. The same firm have fitted their "Tapex" spring mattresses to all berths throughout the first and second-class accommodation, and their "Orex" spring and chain mattresses to all berths in the third-class quarters. They have also supplied the galvanized

Fig. 115.—Second-class Library.

metallic berths for the open steerage, the portable cabins for the temporary third-class, and the whole of the crew's berths.

Promenade Space.

The first-class promenade space on the three uppermost decks is exceptionally fine. The bridge deck (B) promenade can be entirely enclosed. It is a magnificent space over 400ft. long and 13ft. minimum width, on each side of the vessel, and is provided with a solid side screen fitted with the large square lowering windows which constitute one of the most popular features of recent passenger vessels. The windows may be raised or lowered at will, and passengers thus enjoy the conditions they prefer, having an uninterrupted view of the horizon with or without protection from the weather.

Fig. 116.—Windows in Second-class Library.

The principal promenade is situated on A deck, which is entirely devoted to first-class passengers. This promenade is over 500ft. long on each side of the deck and in parts exceeds 30ft. in width. It is covered by the boat deck above, but is open at the sides above the bulwark rail. On the uppermost deck—the boat deck—a space 200ft. long, extending the full width of the ship, is devoted to first-class promenading.

The spaces assigned for second-class promenades are also unusually spacious, and include a length of 145ft. at the after end of the boat deck as well as a covered-in space 84ft. long, with sliding windows at the side, on the shelter deck abreast the second-class library.

The third-class passengers have a promenade on the shelter deck in the after well, and a large covered-in space on D deck forward, which is fitted with tables and seats, and can be used in any kind of weather.

Culinary Department.

No department in a passenger vessel is of more importance to the passengers than that associated with the preparation and service of food, and in no department have greater improvements been introduced during recent years. The difficulty in many ships is to find room for all modern facilities in the limited space allotted to the culinary arrangements. No such disadvantages exist, however, in the *Olympic* and *Titanic*, as the importance attached by the White Star Line to its *cuisine* has led to the provision of ample space for every requirement, and the culinary departments in these ships are among the most complete in the world.

The first and second-class kitchens, serving rooms, pantries, bakeries, sculleries, etc., are situated on the saloon deck between the first and second-class dining saloons, and extend the full width of the ship for a length of nearly 160ft. In the kitchen there are two huge ranges having a frontage of 96ft. and containing 19 ovens, possibly the largest ranges ever made. There are also four silver grills, two large roasters, ranges of steam ovens, steam stockpots, hot closets, *bain-maries*, and electrically-driven triturating, slicing, potato-peeling, mincing, whisking, and freezing machines.

A new departure has been made in the arrangement of the flues. These are all taken below the deck, the object being to minimize the radiation of heat. This is certainly a step in the right direction, and one likely to be followed in future vessels. A large hoist provides communication between the kitchen department and the cold storage rooms.

A vegetable-preparing room, scullery, coal bunker, and larder, provided with all the latest labour-saving appliances, are conveniently arranged on the starboard side of the kitchen. The bakery, which is in itself worth a visit, is placed just aft of the kitchen on the port side. It contains electrically-driven dough-making and other machines, besides water-tube ovens for turning out the very highest class of Vienna table bread. The confectionery department, adjoining the bakery, is fitted with every conceivable

Fig. 117.—Second-class Smoking Room.

appliance for the modern practice of the confectioner's art.

The pantries and service rooms, which have been arranged with a view to obtaining perfect service of hot and cold food, are situated in close proximity to the dining saloons which they serve. There is nothing so annoying as a semi-cold dinner or luncheon, or the long waits frequently experienced when dining in public places. There need be no fear of such happenings on the *Olympic* or *Titanic*. Not a single contrivance for rapid and efficient service has been overlooked. The fittings include *bain-maries*, hot closets, *entrée* presses, silver coffee apparatus, automatic egg-boilers, milk scalders, electric hot plates, and carving tables of the latest design, all carefully arranged to prevent crowding or confusion among the waiters. The cold pantries or stillrooms are also arranged in the most suitable positions to make the service complete.

A separate kitchen, with its own pantry and scullery, is provided for the restaurant, and adjoins the latter on the bridge deck. Access from the lower kitchen is obtained by means of a spiral staircase extending through two decks. The restaurant kitchen, though not so large as the main kitchen, is equally well equipped. There are also separate pantries attached to the various smoking rooms, *buffets*, lounges, parlour suites, etc.

The third-class galley and pantries adjoin the after end of the third-class dining saloon on the middle deck, and are fitted out in a manner which would have been envied by a first-class *chef* some years ago. There is also a large third-class bakery.

The whole of the cooking apparatus has been supplied by Messrs. Henry Wilson & Co., Limited, of Liverpool, than whom no firm has had greater experience in this class of work.

Fig. 118.—Portion of the Third-class Dining Saloon.

Service of Plate.

THE service of plate, which comprises in all about 10,000 pieces, has been supplied by the Goldsmiths and Silversmiths Co., Ltd., of London, a firm who have had great experience with the supply of plate to large hotels. In the case of the *Olympic* and *Titanic* various novel features have been introduced. One of the largest pieces in the service is a massive duck press, which forms a most imposing adjunct. There is also a neat portable spirit lamp, with a quick-heating flame, for keeping warm special sauces and making Turkish coffee. Further novelties are the fruit tymbal and caviar

dishes, in which the contents are kept cool by an ice bath when taken from the cold storage and placed before the passenger.

On the waiting tables are electrically heated Rêchaud stands of the Goldsmiths Company's special type. One of the advantages of this useful article is that any degree of heat, when once obtained, can be retained by a very small consumption of electricity. Another point which may be mentioned is that all handles, covers, parts, and fittings are interchangeable, an arrangement which greatly facilitates cleaning and general utility.

and probably more perfect than any yet attempted on board ship. Broadly speaking, in the case of the large third-class compartments, the principle adopted is to drive in warm air by means of electrically-driven fans, the air being distributed in all directions through insulated trunks. A pleasant temperature is thus maintained even in the coldest weather.

The ventilation and heating of the first and second-class accommodation, on the other hand, involved more special treatment, as the demands of the passengers are so varied. For instance, an American travelling from the Southern States

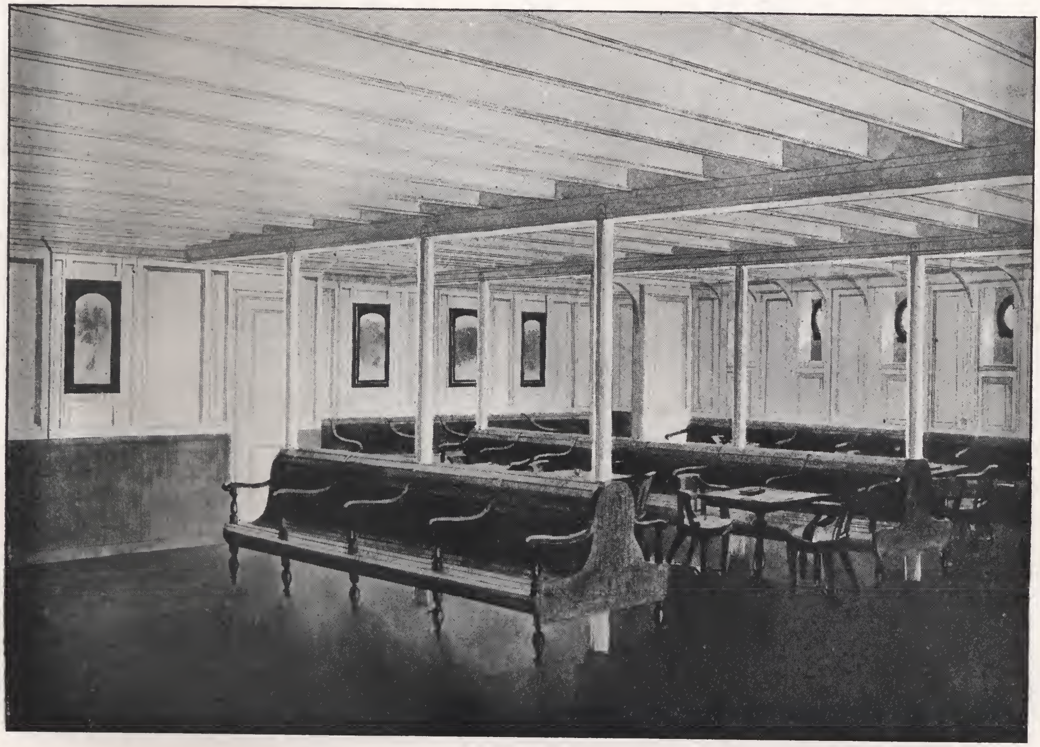


Fig. 119.—Third-class General Room.

The cutlery, spoons, forks, and small wares, numbering over 21,000 pieces, and about 3,000 dishes, tureens, and other larger goods, have been supplied by Messrs. Elkington & Co., of Birmingham.

Ventilation and Heating.

VENTILATION and heating constitute two of the most difficult problems in the arrangement of a large passenger vessel, but the manner in which they have been solved in the case of the *Olympic* and *Titanic* leaves nothing to be desired. Indeed the ventilation and heating system of these vessels is more elaborate

frequently requires, and is accustomed to, an amount of heat which to a Britisher is well-nigh unbearable. With a view to meeting all requirements, after careful thought it was decided to provide an air supply to the passages and individual staterooms which is warmed to a moderate degree, so that an even and pleasant temperature can be maintained. This may be regarded as a warm-air system only, as distinct from a hot-air system, on the "Plenum" method. Each first-class room is also fitted with an electric heater of ample capacity, so that passengers requiring additional warmth can obtain it to the

desired extent, while those who prefer a cooler atmosphere are equalled catered for.

In addition to the hot and warm air delivery fans, there have been provided a large number of suction fans for taking foul air from the lavatories, galleys, pantries, and other quarters, so that not only is fresh air brought into the ship, but all vitiated air is removed from those portions of the accommodation which, unless ventilated, might prove objectionable.

The fans, of which no less than 64 have been required for the ventilation of the accommodation, are all of the "Sirocco" type manufactured by Messrs. Davidson & Co., Ltd., and are driven by Allen motors designed in accordance with Messrs. Harland & Wolff's specification. The motors are provided with both hand and automatic control for the variation of speed to suit the particular system of trunks to which the fans they actuate are connected. This is a very necessary provision, as, if the motors always run at the same speed, they are liable to be either overloaded or to fail in the demands made upon them, it being impracticable to determine beforehand the precise speed required in each case. Three of the fans situated on the boat deck are illustrated in Fig. 120.

The mechanical system of ventilation adopted renders superfluous the numerous cowls which encumber the decks of so many liners, these being, in the case of the *Olympic* and *Titanic*—to use an Irishism—"conspicuous by their absence." For the same reason the space usually sacrificed for the time-honoured domes over the public apartments is utilized in these vessels for other and more advantageous purposes.

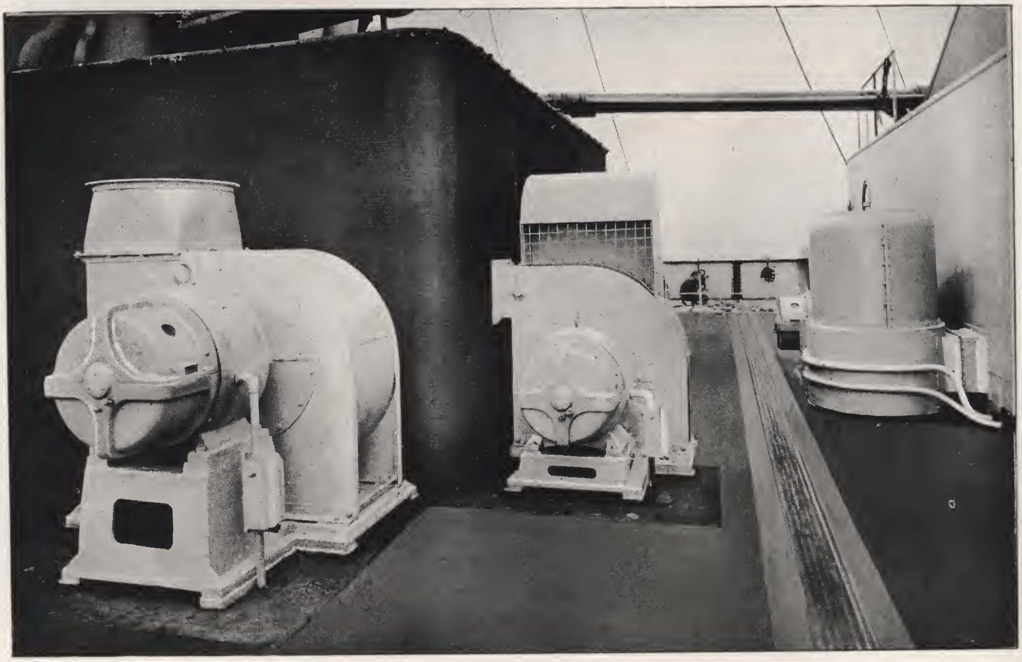


Fig. 120.—Ventilating and Heating Fans on Boat Deck.

Sidelights and Windows.

NATURAL ventilation and the admission of daylight to the interior of the various rooms have been carefully studied, there being about 2,000 windows and sidelights altogether. Indeed the numerous sidelights and the magnificent array of windows form one of the most striking features of the new ships.

Mention has already been made of the novel arrangement of six and four sidelights adopted in the first-class dining saloon and reception room, the oval lights 22in. by 17in. in the first-class staterooms, and the sliding windows of the enclosed promenade. A special glass, supplied by the Maximum Light Window Glass Company, of London, has been used for the inner windows of the dining and reception rooms. By means of the combination of lenses and prisms introduced in this glass, the light from the portholes is dispersed over a greater area than would be the case if ordinary glass had been adopted. All the

public rooms situated on the bridge, promenade, and boat decks have windows of exceptionally large size, as will have been observed from the illustrations already given. Among the largest are the gymnasium windows, shown in Fig. 121.

Passenger Elevators.

The lift service, for which Messrs. R. Waygood & Co., of London, have been responsible, is considerably in advance of that of any previous vessel. The three first-class passenger elevators in each vessel are arranged side by side in one trunkway. Each elevator will raise a load of 15 cwt. between the upper and promenade decks, a height of 37ft. 6in., at a speed of 100ft. per minute. The cages are about 5ft. 4in., by 6ft., by 7ft. high, and are made of dark mahogany. Each cage has a glass roof and ventilator, and is furnished with a portable upholstered seat and an electric lamp. The entrance is fitted with a collapsible gate, which is electrically locked and must therefore be closed before the lift can be started.

The winding gear is fitted directly overhead, and is driven by a special slow-speed motor to ensure quiet running. The gear consists of a steel worm and a phosphor bronze worm wheel, enclosed in a cast iron case forming an oil bath. The thrust of the worm shaft is taken by double-ball thrust bearings. The gear is fitted with a winding drum, having two steel wire ropes connected to the cage and two separate ropes for the counter-balance weight. An automatic electric brake comes into action when the current is shut off for any reason. The controller for electric operation is worked by a car switch in the cage, with a self-centring detachable handle. Special provision is made to guard against over-running in either direction in case of inattention on the part of the operator or any failure in the controller. The cages are guided by round turned steel runners, in order to give the smoothest possible movement in the lift, and are counter-balanced by a cast iron weight working also on round steel runners.

Fig. 121.—Gymnasium Windows.

A novel feature of the lift service is the provision in the second-class accommodation of a passenger elevator, also supplied by Messrs. Waygood. This lift is practically identical with the first-class passenger elevators, except that the cage is more plainly furnished.

The Electrical Equipment.

ELECTRICITY, it need hardly be pointed out, is extensively employed in all the departments of the *Olympic* and *Titanic*. In addition to the large supply required for lighting purposes, electrical power is used for the deck cranes ; cargo, boat, and engine room winches ; passenger elevators ; stores, mail, and pantry lifts ; ventilating and stokehold fans ; cabin fans ; motors for the cylinder-lifting gear, turbine-turning and lifting gear, and condenser sluice valves ; the workshop machine tools ; conveyor for marconigrams ; gymnastic apparatus ; kitchen and pantry machinery, such as the ice-rocker, dough-mixers, potato-peelers, roasters, knife-cleaners, mincers, hot plates, and electric irons ; electric heaters ; electric baths ; main steam whistles ; sounding machines ; stoking indicators ; boiler room telegraphs ; clocks ; watertight doors ; helm indicator ; illuminated pictures ; chimes ; bells ; loud-speaking and service telephones ; submarine signalling ; and wireless telegraphy. The electrical installation, therefore, may virtually be termed the nerve system of the ship. Indeed the application of electricity is so general that much of the electrical equipment is necessarily described in the other sections of this book.

Central Station.

THE central station is situated in a separate watertight compartment, about 63ft. long and 24ft. high, adjoining the after end of the turbine room at the tank top level. The general arrangement of the electrical machinery in this compartment is shown in Fig. 122. The main generating plant consists of four 400-kilowatt engines and dynamos, manufactured by Messrs. W. H. Allen, Son & Co., of Bedford, and has a collective output of 16,000 amperes at 100 volts, which exceeds in current capacity many large city central stations. The switchboard gallery is at the forward end of the compartment at the orlop deck level, and commands a view of the machines.

Main Generating Sets.

THE engines are of the vertical three-crank compound forced-lubrication type and indicate 580 horse-power each when running at 325 revs. per minute. Each engine has one high-pressure cylinder 17in. diameter and two low-pressure cylinders 20in. diameter, with a stroke of 13in. Steam is supplied at 185lb. pressure and is exhausted either into the surface heater, which is the condition at sea, or into the auxiliary condenser, which is the condition in port. Each engine is coupled directly to a compound-wound continuous-current dynamo of the ten-pole type fitted with inter-poles. The equalizer cables are led to the equalizer switches situated below the deck near the centre of the compartment, with a view to minimizing and equalizing the resistance when running in parallel. Illustrations of one of the generating sets are given in Figs. 123 and 124. The tachometers are driven by Hans Renold silent chains.

Auxiliary Generating Sets.

IN addition to the four main generating sets, there are two 30-kilowatt engines and dynamos situated on a flat in the engine casing at the saloon deck level, well above the water-line. The general features of their design are similar to the main sets, except that the engines are of the two-crank compound type. Each engine has cylinders 9in. and 12in. diameter by 5in. stroke, and runs at 380 revs. per minute. The auxiliary sets are connected by means of a separate steam pipe to boilers situated in either of several boiler rooms, and will be available for emergency use should the main sets be temporarily put out of action.

Main Switch Gear.

CURRENT is conveyed from the main dynamos by means of heavy rubber-insulated cables, each of 1·5 sq. in. sectional area and $2\frac{1}{4}$in. diameter, to the dynamo control switches situated on the front of the switchboard gallery. Of these there are four, one for each dynamo, each provided with five hand levers resembling those commonly seen in a railway signal box ; see Fig. 125. The electrician in charge faces the machinery when operating the switches, and can also communicate his instructions to the engineer below by means of electrically illuminated signals which signify if any particular set is to be started, stopped, or varied in speed. The various switches are interlocked to ensure correct operation. Four ammeters, reading up to 5,000 amperes each, are provided, and there are also four integrating wattmeters, which

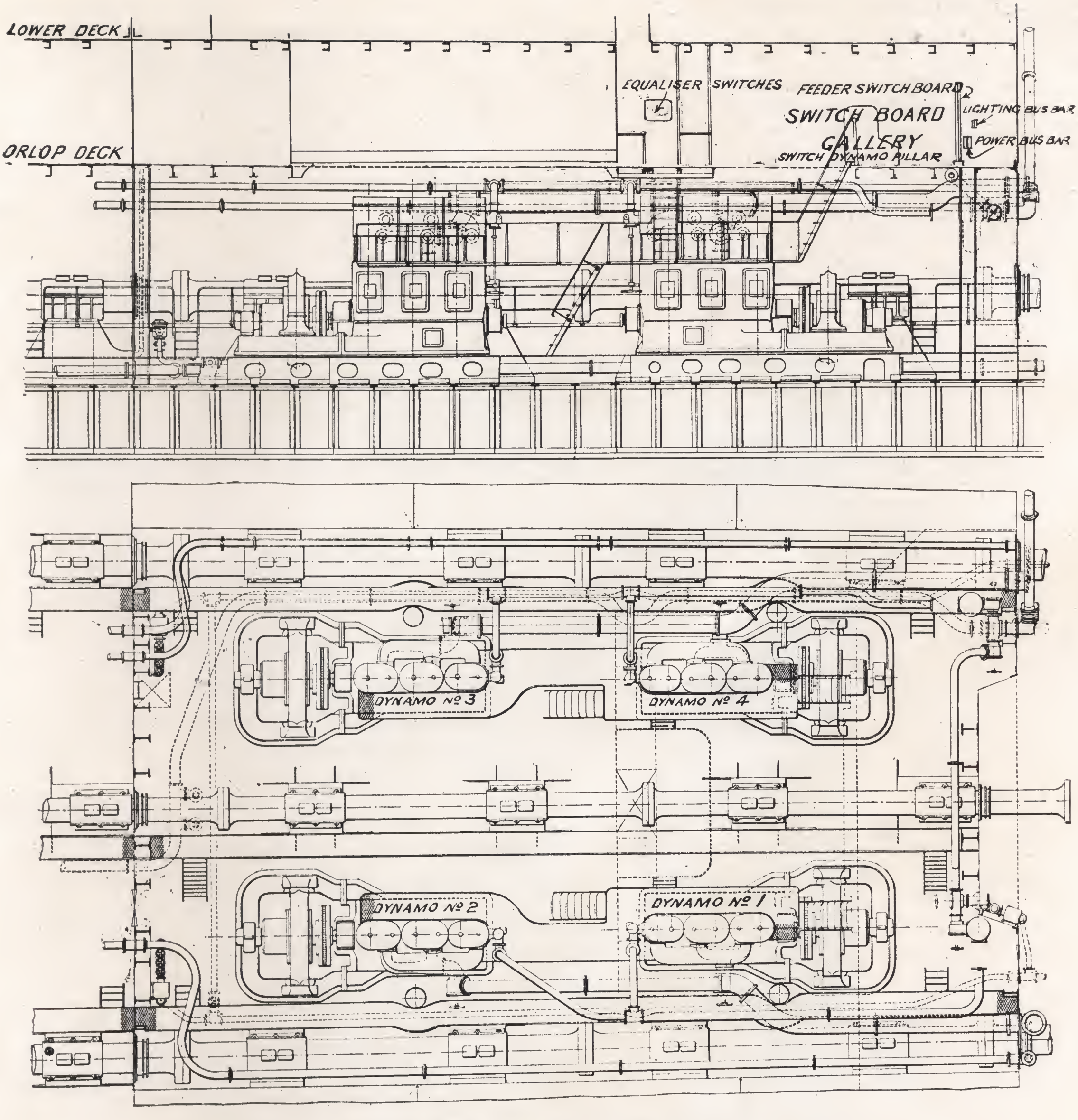


Fig. 122.—Arrangement of Electric Engine Room.

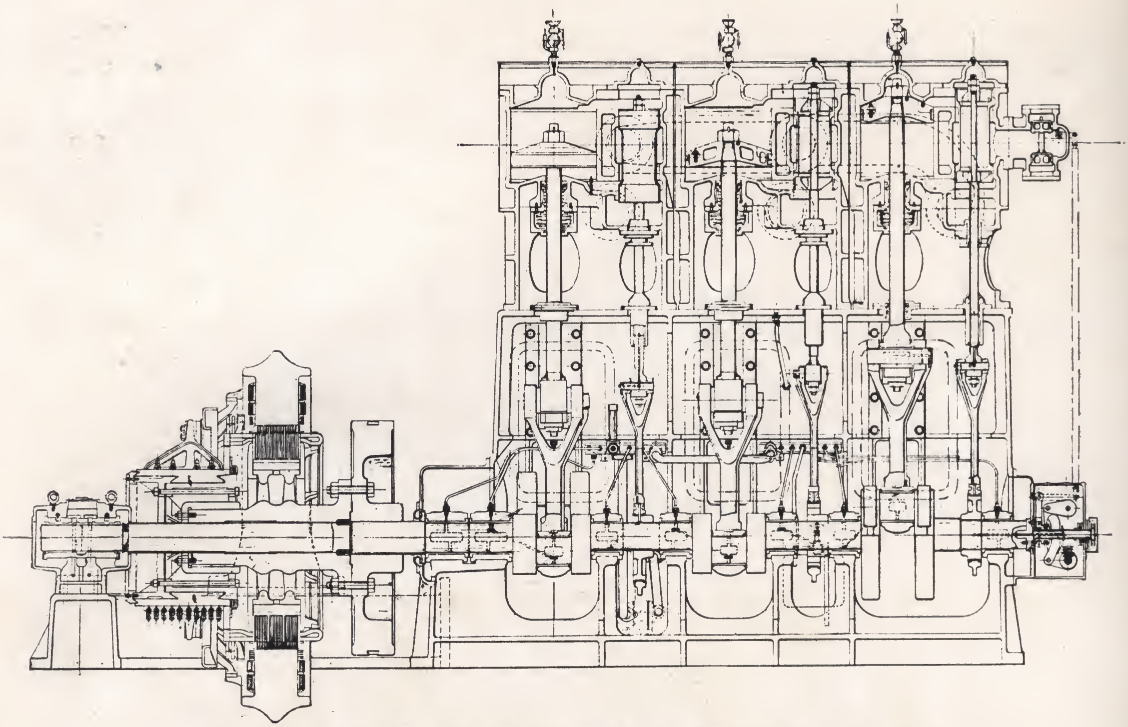


Fig. 123.—Sectional Elevation of one of the Main Generating Sets.

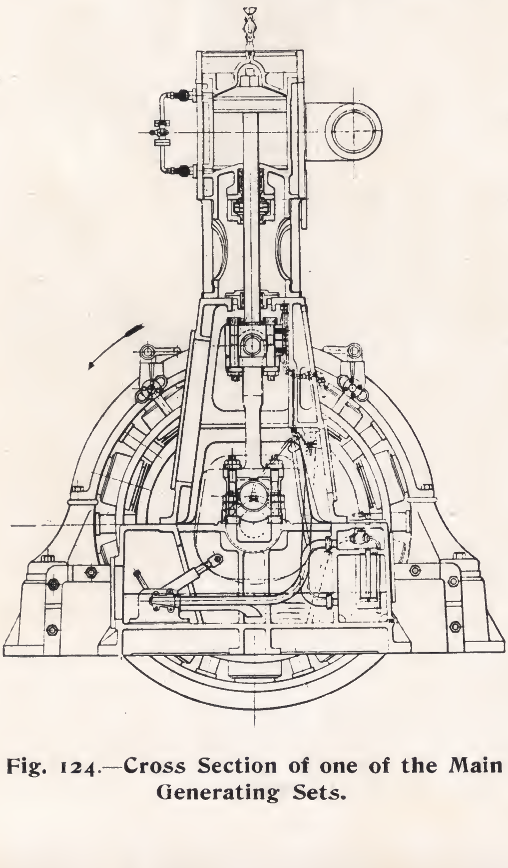


Fig. 124.—Cross Section of one of the Main Generating Sets.

record the number of units generated by the several dynamos. For guidance in coupling or uncoupling the sets, four revolving voltmeters are mounted on a stand between the dynamo pillars, and indicate the electrical pressure at the lighting and power bus-bars and any individual dynamo.

Feeder Switchboard.

From the main dynamo switches the current passes by insulated cables below the gallery to the feeder switchboard. The latter consists of 25 black polished slate panels, upon which are mounted the fuses, automatic cut-outs, and ammeters for controlling each circuit. A general view of the feeder switchboard and its attendant apparatus, which have been constructed by Messrs. Dorman & Smith, of Salford, Manchester, to the shipbuilders' specification, is shown in Fig. 126.

Branch Circuits.

From the feeder switchboard radiate no fewer than 48 cables, ranging in area up to 61/12 S.W.G. The distribution of current is effected on the single-wire system, but the returns are carried back and bonded in such a way as to avoid stray currents. The power and heating supply can be run entirely independent of the lighting supply, there being power and light bus-bars on the switchboard which can be paralleled or otherwise, as may be required. The

cables pass vertically up two steel trunkways, one on the starboard and one on the port side, and terminate in master fuse boxes at each deck, from whence branch the individual circuit cables. The latter ramify throughout the vessel along the main passages of the different decks, and feed in turn the distribution boxes, one of which is illustrated in Fig. 127. From the distribution boxes the current is taken by wiring to the individual lights, motors, heaters, etc. Local switches are, of course, provided for turning off individual lights or machines.

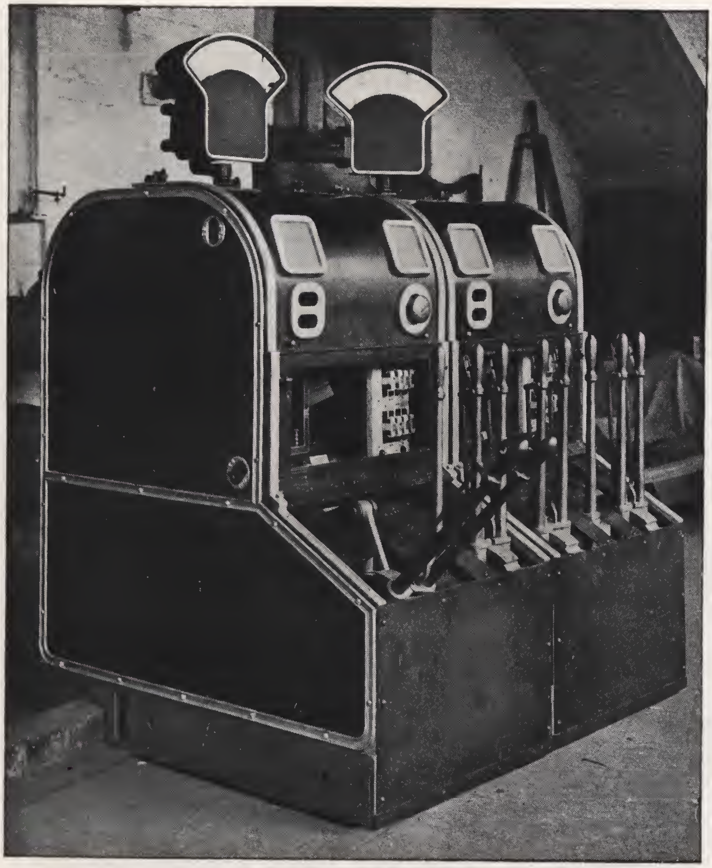


Fig. 125.—Switch Gear of Dynamos 3 and 4.

Cables.

The main cables and branch wires are of tinned copper covered with rubber and heavily braided, except in the machinery spaces, where they are lead sheathed, armoured, and externally braided. In the boiler rooms the cables are run in steel pipes for protection against damp and mechanical injury. All wires leading through a watertight bulkhead are collected together in a steel tube filled with bitumen to ensure watertightness and yet look neat. Some idea of the extent of the electrical system will be gathered when it is stated that considerably more than 200 miles of cable have been fitted on each ship.

Electric Lighting.

The total number of incandescent lamps installed on board the *Olympic* is about 10,000, ranging from 16 c.p. to 100 c.p., the *Titanic* having a similar number. Tantalum lamps have been adopted throughout, except in a few cases in the engine room, the metal filament lamps having been found quite suitable for use on shipboard except where there is any pronounced vibration. Their use permitted the voltage to be reduced to 100. The economy secured by the reduced voltage more than compensates for the higher first cost of the metal filament lamps compared with the ordinary incandescent pattern.

In the first-class staterooms, in addition to the usual fixed lights, there are fitted sockets for portable electric lamps or fans. Special dimming lamps with two filaments are also provided so that a light of small candle-power can be kept burning throughout the night, a feature which will appeal to nervous passengers.

Emergency lamps on distinct circuits, deriving current from the emergency dynamos, are placed at intervals in all the passages, public rooms, and compartments throughout the vessel, so that, in the unlikely event of an entire extinction of the ordinary lighting, there would still be illumination available at all the points where the passengers and crew would congregate. In fact, anyone could find their way from one end of the vessel to the other at night by means of the lights on these circuits.

Many of the electric light fittings in the passenger accommodation are of majolica, which does not tarnish like metal. The ormolu electric light fittings have been supplied by Messrs. N. Burt and Co., Limited, of London. In the public rooms, main entrances, and suite rooms, these fittings are of a magnificent character, designed to agree in style with the particular period of decoration employed, and ranging from severe Italian Renaissance to elaborate Louis Seize. The main staircase fittings are after original French models. No trouble or expense has been spared in their selection, some having cost many hundreds of pounds each. Illustrations of these fittings will be found elsewhere in the chapter dealing with the passenger accommodation.

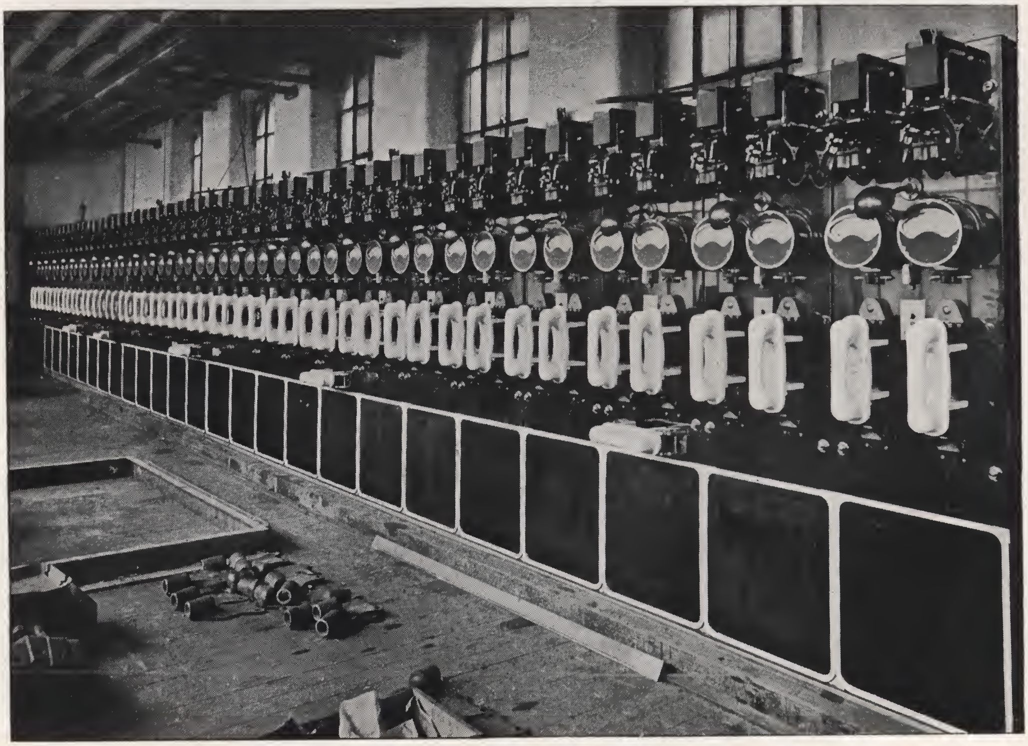


Fig. 126.—Main Feeder Switchboard.

Electric Bells.

THE electric bell installation comprises no fewer than 1,500 bell pushes on each ship. In the staterooms the bell pushes are mounted on the same plates with the electric light switches, such a plate being placed within convenient reach of each berth.

Electric Heaters.

THE electric heaters, of which there are 520 installed throughout each vessel, are of the Promotheus type, illustrated in Fig. 128. These heaters take a collective current of over 5,000 amperes.

Electric Motors.

AN idea of the large number of motors required will have been gathered from the numerous types of electrically driven machinery already cited. Altogether there are

150 motors on board, varying from $\frac{1}{2}$ to 40 H.P. Of these, 76 are employed in driving the ventilation fans, and take a collective current of 5,250 amperes. The method of hand and automatic control adopted for the fan motors has already been dealt with when describing the stokehold

Fig. 127.—Electrical Distribution Box.

fans and the ventilation and heating arrangements. Next in order to the fan motors as regards the amount of power absorbed come the various motor-driven machines and mechanisms in the engine rooms, the cargo cranes and winches, the elevators and hoists, and the domestic machinery.

Electric Cargo Cranes.

To secure the minimum of noise and vibration, electrical driving has been adopted for the cargo cranes and winches in the vicinity of the passenger accommodation. Eight electric cargo cranes have been supplied to each ship by Messrs. Stothert and Pitt, Ltd., of Bath, six having a capacity of $2\frac{1}{2}$ tons each and two of $1\frac{1}{2}$ tons each. Two of the $2\frac{1}{2}$-ton cranes are placed at the third hatch forward (see Plate III.), and have a radius of 27ft., a height from the deck to the centre of the pulley of 29ft., and a total lift of 100ft. The remaining four $2\frac{1}{2}$-ton cranes are placed at the after hatches, Nos. 5 and 6. The radius is somewhat greater than in the case of the forward cranes, two having a radius of 28ft. and the other two 29ft.; but the height to the centre of the pulley is slightly less, being 27ft. and 26ft. respectively instead of 29ft. In the case of all the $2\frac{1}{2}$-ton cranes the hoisting motor is of 40 B.H.P. and the slewing motor of 5 B.H.P. The lifting speed at full load is 160ft. per minute, and the slewing speed 500ft. per minute. The lifting speed increases automatically for lighter loads. One of the $2\frac{1}{2}$-ton cranes is shown in Fig. 129.

The two $1\frac{1}{2}$-ton cranes are placed at the after end of the promenade deck, and serve the two small hatches to No. 4 hold. Their radius is 21ft., height between deck and pulley 20ft., and total lift 80ft. Each crane is fitted with a hoisting motor of 30 B.H.P. and a slewing motor of 3 B.H.P. The lifting speed at full load is 200ft. per minute, and the slewing speed is 500ft. per minute.

Electric Winches.

Four 3-ton electric cargo winches and four 15-cwt. boat-hoisting winches have been supplied to each ship by the Sunderland Forge and Engineering Co., Ltd., and have been so designed by the makers that vibra-

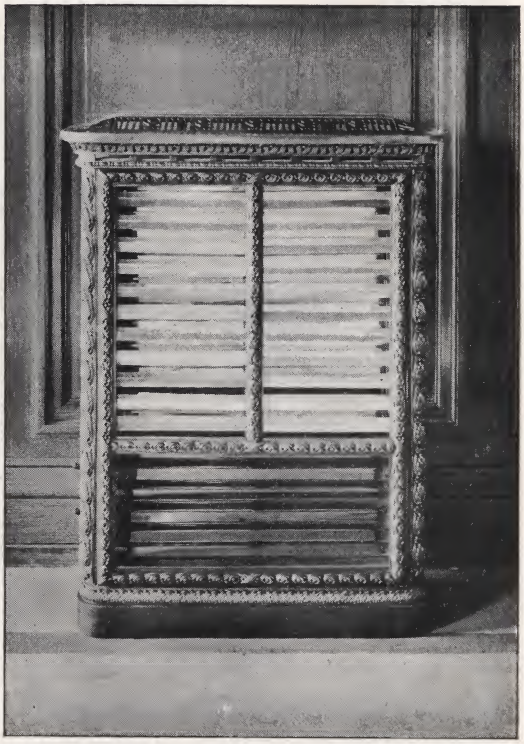


Fig. 128.—Electric Heater.

tion and noise are practically eliminated. In the case of both sizes the lifting speed is 100ft. per minute at full load. As the winches are situated on the open decks, the working parts and motors are made totally enclosed and watertight. The warping ends are driven through worm gearing of very substantial construction, the whole being

enclosed and running in an oil bath. Ball thrust blocks are provided on the worm shafts.

The motors are series-wound, and equipped with all the necessary control gear. A magnetic brake and also a foot brake are provided on each size of winch, the latter brake being interlocked with the controller to prevent abuse of the motor by unskilled operators.

The controllers and resistances are built with a view to withstanding the roughest treatment. Particular attention has been paid by the makers to the insulation of the current-carrying parts, on account of the damp and salt atmosphere to which the machines will be exposed. One of the winches is illustrated in Fig. 130.

There are also electric winches in the engine room in connection with the lifting gear, which have been supplied by Messrs. Chambers, Scott and Co., of Motherwell.

Elevators and Lifts.

The winding gear for each of the first and second-class passenger elevators, which have already been described when dealing with the passenger accommodation, is driven by a motor of the four-pole totally enclosed shunt-wound type, rated at 6 B.H.P. when running at a speed of 500 revs. per minute, the rating being on the basis of a six-hours run with full load and a rise of temperature not exceeding 70° F.

Besides the passenger elevators there is, on each ship, a 3-cwt. electric service lift in the officers' pantry and another in the restaurant pantry. The latter travels from the saloon to the bridge deck, a height of 19ft. 6in., and has a cage 1ft. 7in., by 2ft. 2in., by 2ft. 6in. There is also a 10-cwt. stores lift (depicted in Fig. 131) for carrying provisions, etc., from the storerooms to the saloon deck, a height of 33ft. 6in., and an 8-cwt. lift forward for raising mail bags. All the service lifts are electrically controlled by push buttons placed at each deck. Position indicators and speaking tubes are also provided. All the lifts have been constructed and fitted on board by Messrs. R. Waygood & Co., Ltd., of London.

Fig. 129.—2½-ton Electric Crane.

Electric Baths.

Two electric bathrooms of the most modern type have been arranged adjacent to the Turkish baths at the middle deck level. The type of bath fitted is illustrated by Figs. 132 and 133. Fig. 132 shows the bath open and Fig. 133 shows the bath closed up and in use.

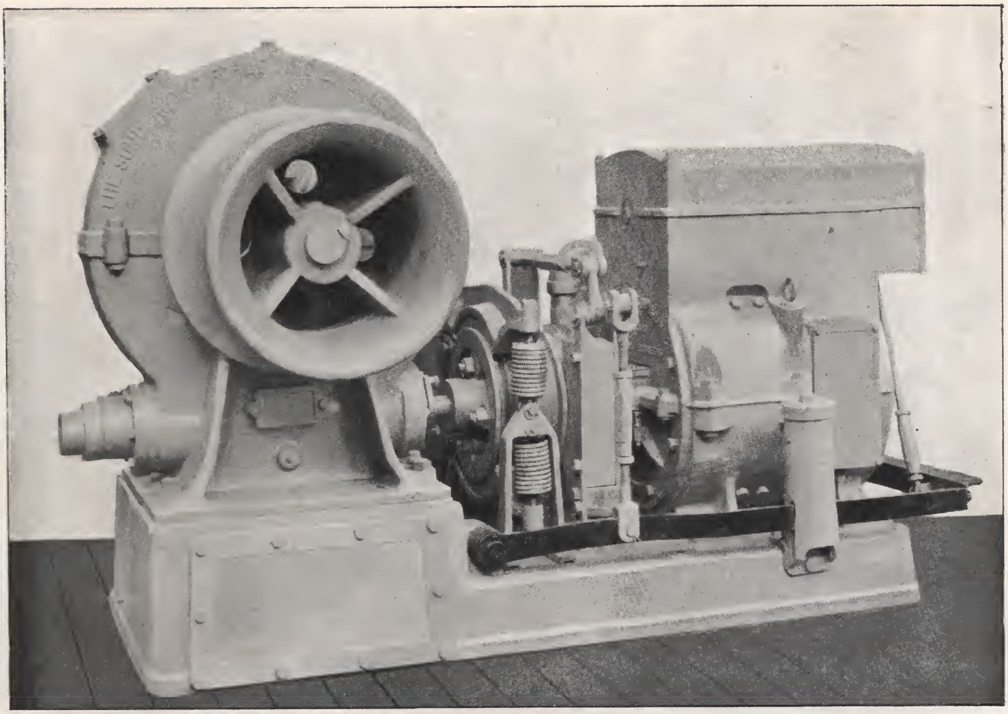


Fig. 130.—3-ton Electric Cargo Winch.

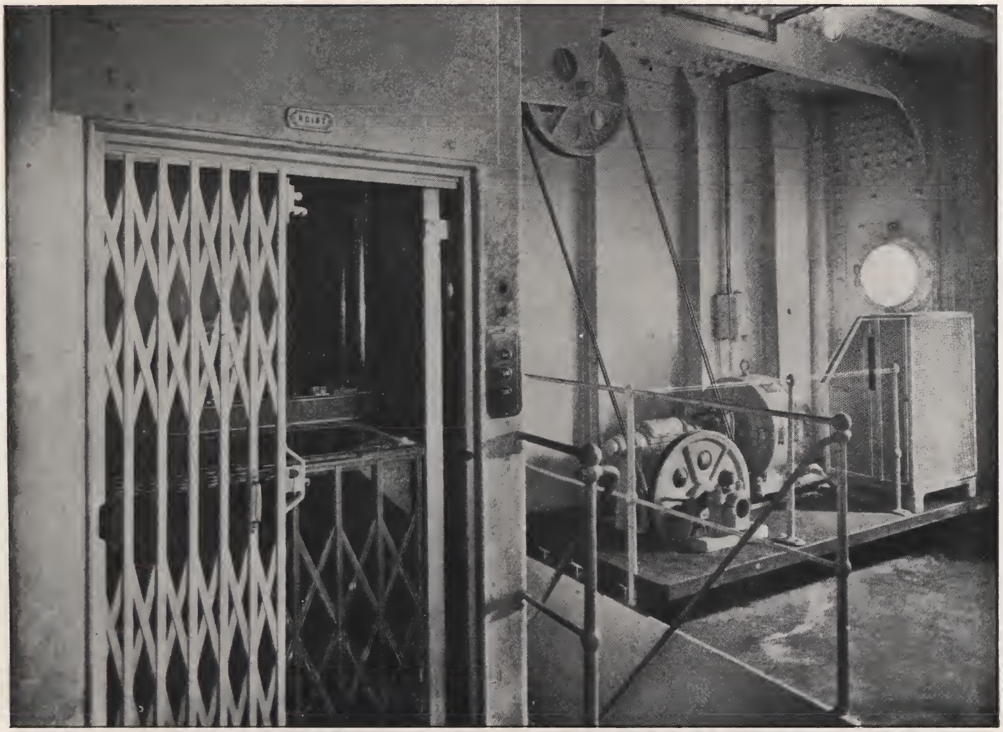


Fig. 131.—10-cwt. Stores Lift.

Fig. 132.—One of the Electric Baths, open.

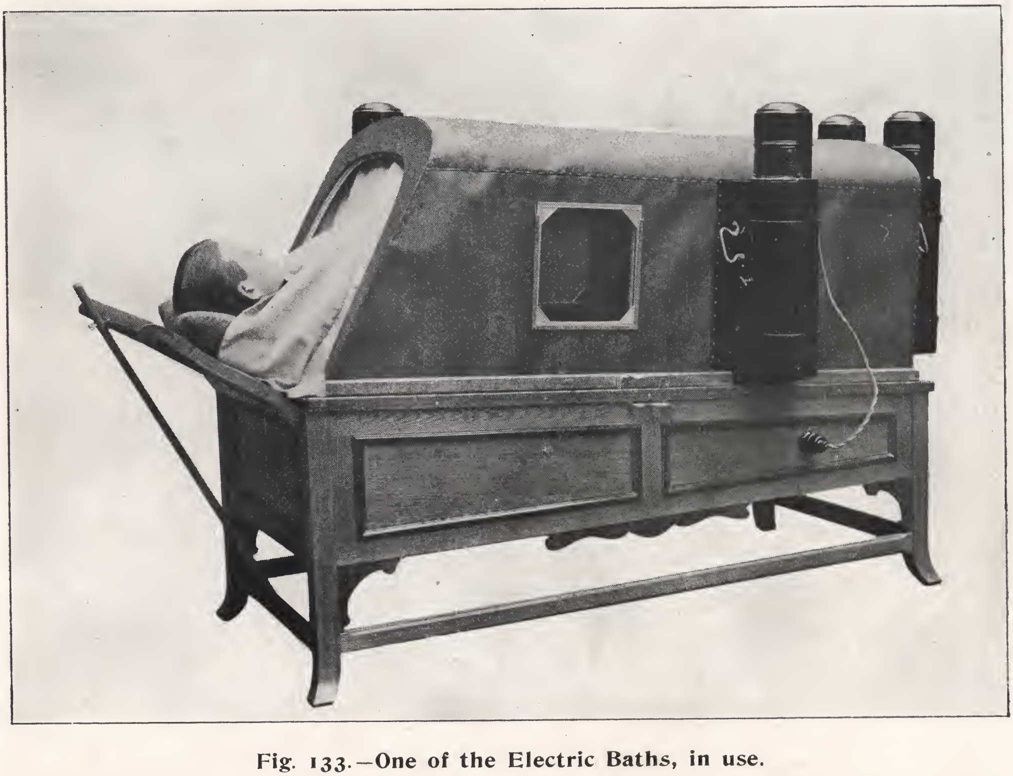


Fig. 133.—One of the Electric Baths, in use.

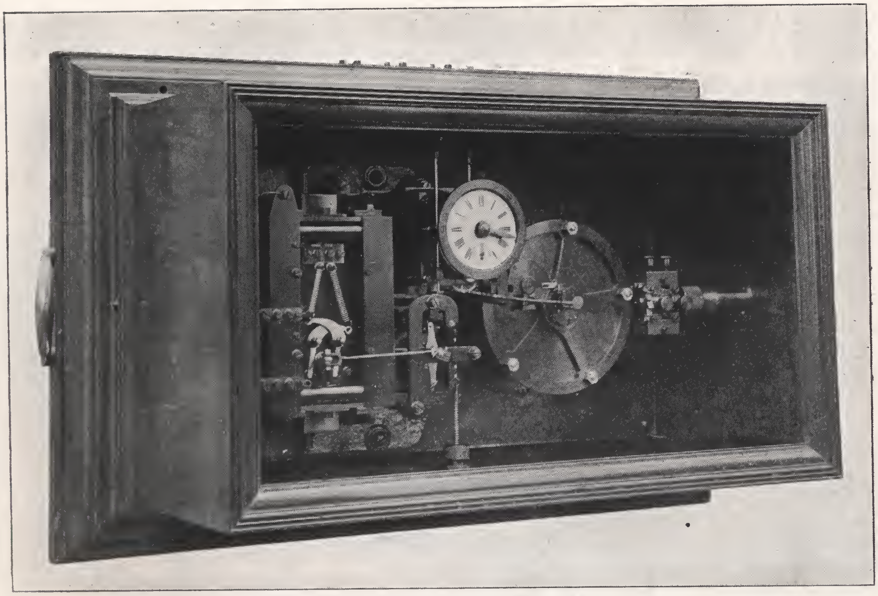


Fig. 134.—One of the Master Clocks.

Magneta Clocks.

The clocks, of which there are 48 throughout each vessel, have been supplied by the Magneta Time Co., Ltd., and all are actuated electrically on the Magneta system, which obviates the use of galvanic batteries. They are controlled by two master clocks placed in the chart room, so that they may work in complete unison and each register exactly the same time. One of the master clocks is illustrated in Fig. 134. As is well known to ocean travellers, the ship's clocks gain over half an hour each day when going westwards and lose a corresponding amount when returning to Europe. To allow for this difference in time the master clocks are set each day at noon by the officer in charge, who puts them backwards or forwards according to the longitude.

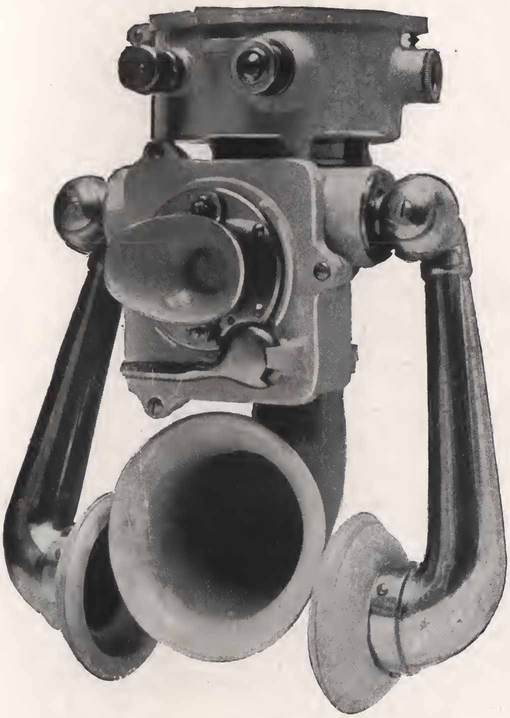


Fig. 135.—Loud-speaking Telephone.

Illuminated Signs and Pictures.

A number of electrically illuminated signs are distributed throughout the first and second-class accommodation to direct passengers to the respective main entrances and public rooms, while on view in the gymnasium are attractive illuminated multi-coloured pictures of sections of the *Olympic* and *Titanic*, and a map of the world with a network of the many White Star steamship routes which encircle the globe.

Telephone Installation.

The telephone installation of the *Olympic* and *Titanic* is divided into two sections, *viz.*, the navigating group and the internal system. All the apparatus is of the very latest type and has been installed on the most approved lines. The navigating group provides for communication between the following :—

The wheel house on the bridge and the forecastle.

- The wheel house on the bridge and the crow's nest.
- The wheel house on the bridge and the engine room.
- The wheel house on the bridge and the poop.
- The chief engineer's cabin and the engine room.
- The engine room and Nos. 1, 2, 3, 4, 5 and 6 stokeholds.

The instruments employed are Messrs. Alfred Graham and Co.'s patent loud-speaking navy 'phones of the type illustrated in Fig. 135. Except in the chief engineer's cabin, the telephones are of the " Universal " pattern, by which

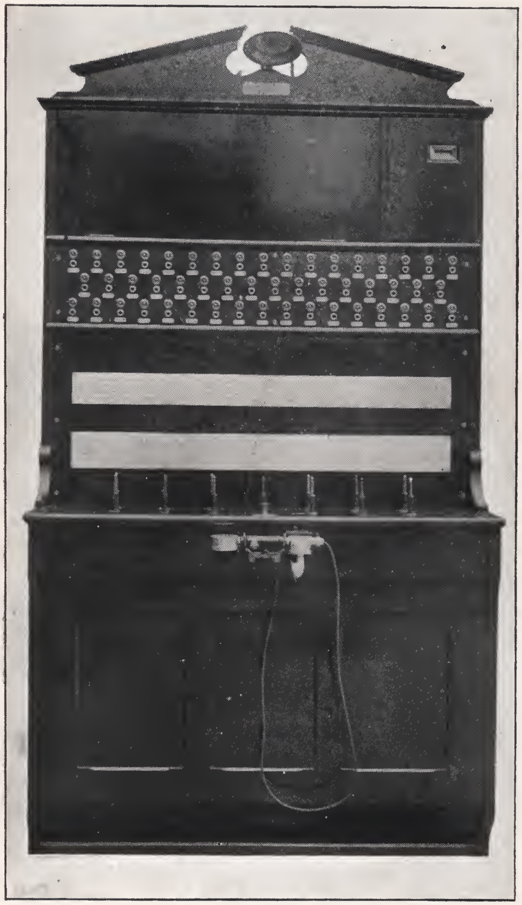


Fig. 136.—Telephone Exchange Switchboard.

calls are given by means of an interrupter as well as by voice. The apparatus is mounted in special forms to suit the various positions. On the forecastle and poop the instruments are contained within a polished brass casing mounted on a pillar, and the whole fitting is arranged in portable form, so that the apparatus can be used at two alternative positions in the case of the forecastle set and at a second position on the poop. For the crow's nest the telephone is mounted

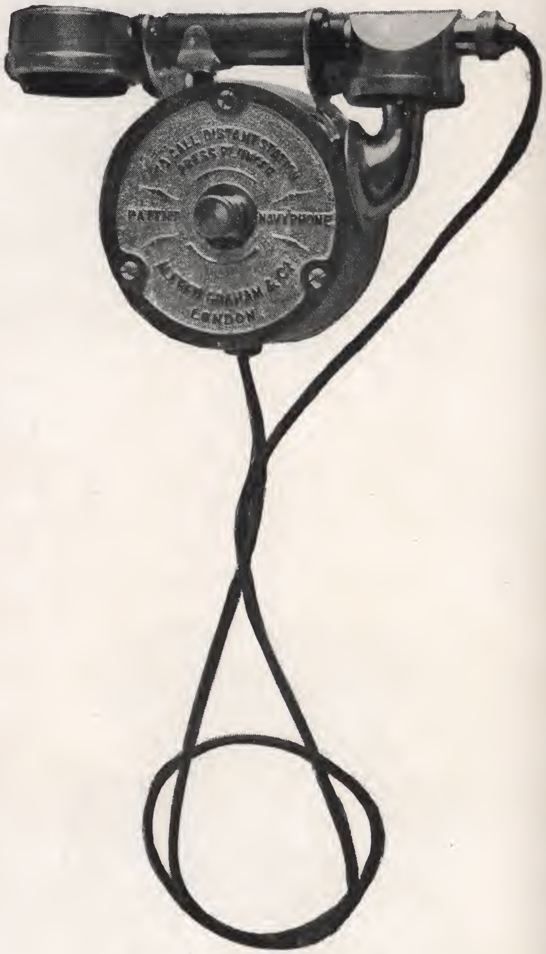


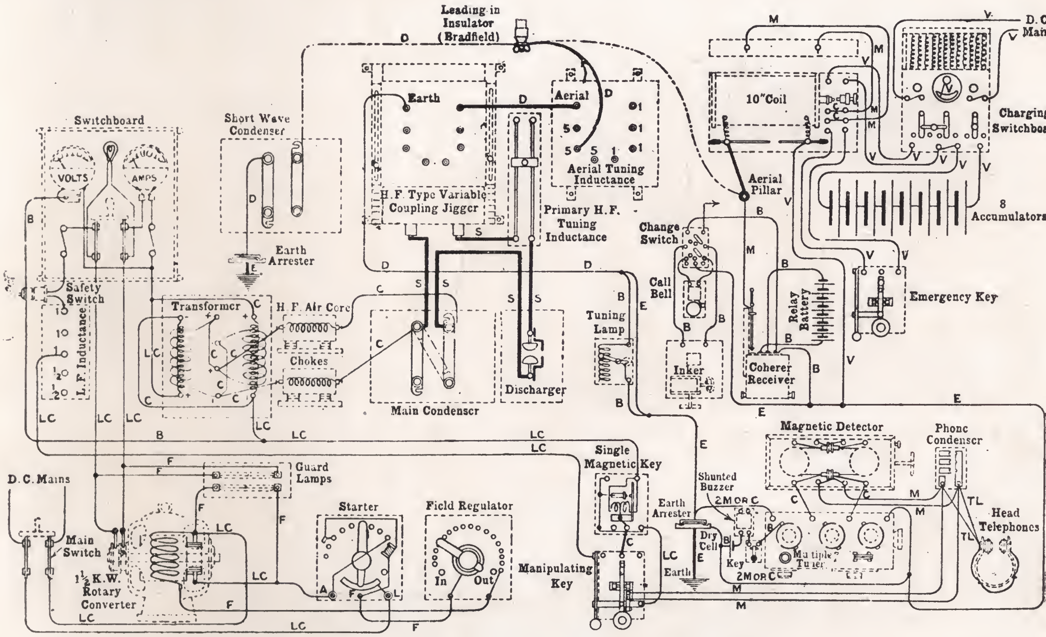
Fig. 137.—Cabin Telephone.

within a metal hood, and this set also is portable. In the wheel house on the navigating bridge four instruments are fitted. Each telephone is provided with an indicating device, and, in addition to a flag showing as is usual, a signal lamp is caused to glow upon a call being received. In the engine room three telephones are employed, and the instrument for communicating with the boiler rooms operates in conjunction with a combined switch and indicator giving both lamp and flag signals, as in the case of the bridge instruments. In each boiler room the telephone is mounted within a metal hood, and a special

calling receiver is provided at each station, as well as a visual indicator. The telephone in the chief engineer's room is of the cabin type.

The current for operating the system is obtained from the ship's lighting circuit, which is reduced to a pressure suitable for telephonic work by means of resistances, and the noise of commutation, inherent in the machine-generated supply, is eliminated by the introduction of inductance coils. A standby battery is also provided, and is introduced in the circuit, should the main supply fail, by means of an automatic switch.

The internal system provides for intercommunication between a number of cabins through a central exchange. The exchange switchboard has a capacity of 50 lines, the stations connected being a number of first-class staterooms and also the rooms of the chief officials and various service rooms. The switchboard, which is illustrated in Fig. 136, is arranged to give a lamp signal upon a call being made, and in addition to the usual audible signal a voice call can be given to the exchange from any station in connection, so that rapidity of operation is assured. The user at one of the cabins has simply to pick up the telephone and say straightaway the station he wishes to speak to and a loud receiver at the exchange gives the instruction. The operator, seeing a lamp glowing corresponding with the calling station, then connects the calling station with the station required, thus obviating the usual delay in communicating with the calling station and ascertaining the position required. The current supply is obtained from the lighting circuit, as in the case of the navigating telephone system, and the automatic switch and standby battery are contained within the exchange switchboard casing. The telephone sets in each cabin are of Graham's intermediate loud-speaking type (Fig. 137), and comprise a hand set with a circular metal push and terminal box. At the majority of the positions the fittings are silver-plated, and at others of polished and lacquered brass. The wiring of the system has been planned on the most approved principles, and junction boxes have been introduced so as to facilitate testing and extension of the installation.



Reference to Wiring: LC = $\frac{7}{16}$ Lead Covered. I = $\frac{1}{16}$ Lead Covered. M = Silk Marone Flex. C = No. 10 Bare Copper. B = Bell Wire.
S = H.F. Copper strip connectors. D = Dynamo Fl... E = Earth Wire. TL = Telephone Leads. V = $\frac{7}{16}$ I.R.V. B. Cable.

Fig. 138.—Connections of 1½-kw. Marconi Converter Set.

In addition to the exchange system, a separate group of circuits is provided for direct communication between the following :—

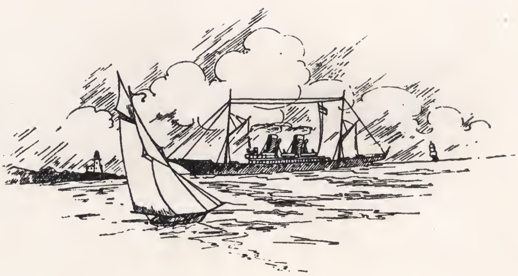
First-class pantry (port) and galley.
First-class pantry (port) and baker's shop.
First-class pantry (port) and butcher's shop.
Second-class pantry and baker's shop.
Second-class pantry and galley.
First-class pantry (starboard) and galley.

These telephones are identical with those on the exchange system. At the first-class pantry, a three-way switch and indicator box are fitted, and in the baker's shop and second-class pantry two-way switches and indicators are provided.

The telephones and fittings have been manufactured by Messrs. Alfred Graham & Co., at their Crofton Park Works, London, and the work of erection on board has been carried out by their own staff.

Wireless Telegraphy.

THE wireless telegraphy installation consists of a Marconi $1\frac{1}{2}$-kilowatt standard ship's set. The house for the Marconi instruments is situated on the boat deck adjoining the officers' cabins; see Plate III. The two parallel aerial wires required for the system extend between the masts, as indicated in Plate III. They are kept as high as possible and are fastened to light booms, the latter being attached to the masts. From the aerial wires, connecting wires are led to the instruments in the house. There are two complete sets of apparatus, one for transmitting and one for receiving messages, the latter being placed in a sound-proof chamber built in one corner of the house. It does not lie within the province of this work to describe in detail the Marconi apparatus; but to give some indication of its nature Fig. 138, showing the connections of a $1\frac{1}{2}$-kilowatt converter set, has been reproduced from an interesting article on the subject by Mr. W. W. Bradfield in a recent number of *The Electrician*, to which we would refer readers desiring further information.



Working Arrangements of the Ships.

THE working arrangements on board the *Olympic* and *Titanic* are necessarily on a scale in keeping with the great size of the vessels. The number of crew employed on board each ship for all purposes is about 860. Of these about 65 belong to the navigating department, 320 are employed in the engineers' department, and 475 are engaged in the stewards' and catering department. The forward portion of the boat deck and the exposed decks at the ends of the vessel are entirely devoted to working and navigating appliances, while the management of the ship is also greatly facilitated by the working passage on the port side of E deck, which extends nearly the full length of this deck and is connected by stairways with all the principal departments.

Accommodation for Officers and Crew.

THE position of the officers' and crew's accommodation will be seen from Plates III., IV. and V. The officers are accommodated in a house on the boat deck forward. The engineers' quarters are on the middle deck, and their mess room, pantries, offices, etc., on the deck above adjoining the working passage. The firemen have excellent accommodation on five decks right forward. Access from their quarters to the boiler rooms is obtained by two spiral staircases and a tunnel through the forward holds, an arrangement which keeps the firemen entirely clear of the passenger accommodation. The seamen's accommodation is placed on E deck forward. The living rooms for the stewards and catering staff are situated on the port side of E deck, and are entered from the working passage.

Cargo, Baggage, and Mails.

To provide access for cargo or baggage to the lower holds, three cargo hatchways, placed at the centre-line of the ship, have been fitted forward for Nos. 1, 2 and 3 holds ; four hatchways have been provided aft, two placed at the centre-line for Nos. 5 and 6 holds ; and two smaller hatchways, away from the centre-line, give access to No. 4 hold. The hatchways to Nos. 1 and 2 holds are served by three steam winches. The third hatch, that near the passengers' quarters, is served by two 2½-ton electric cranes and two 3-ton electric winches. The two hatchways to No. 4 hold are each served by a 1½-ton electric crane. The remaining hatchways, Nos. 5 and 6, are each served by two 2½-ton cranes and one 3-ton electric winch. The masts, which have a height of 205ft. above the average draught line, are utilized for working the cargo by means of cargo spans, while the foremast supports a derrick suitable for lifting motor cars, which will be stored in one of the fore holds.

The post office and baggage accommodation is arranged compactly on the lower and orlop decks forward, with a view to expediting the reception and despatch of the mails and the transportation of passengers' baggage on the departure and arrival of the ship.

The Navigating Bridge.

THE navigating bridge, from which the vessel is controlled, is situated at the forward end of the boat deck, so that the navigating officer may have a clear view ahead. This bridge is a veritable forest of instruments. In the centre is the wheelhouse, containing the telemotor control wheel by which the ship is steered, with a standard compass immediately in front. In front of the wheelhouse are placed the engine room, docking, and steering telegraphs, and loud-speaking telephones to various stations. In the bridge shelter or chart room adjoining are also placed the watertight door controller, the submarine-signal receiver, the helm indicator, the master clocks, and other apparatus.

There is also a docking bridge provided right aft, for use when the vessel is docking or turning in a confined space.

Steering Gear.

THE steering gear is situated in the poop at the after end of the shelter deck. It is of the well-known Wilson-Pirrie type, made by Messrs. Harland & Wolff themselves, and consists of a spring quadrant and tiller on the rudder-head worked through wheel-and-pinion and bevel gearing by either of two sets of three-crank vertical steam engines. Either engine suffices for the working of the gear, the other being a standby. The whole arrangement is illustrated in Fig. 139. The engines have inverted direct-acting cylinders, each 17in. diameter by 18in. stroke, which take steam at a pressure of 100lb. per sq. in. Piston steam valves have been adopted, and work directly from the crank shaft by means of eccentrics.

The cylinders of each engine are supported at

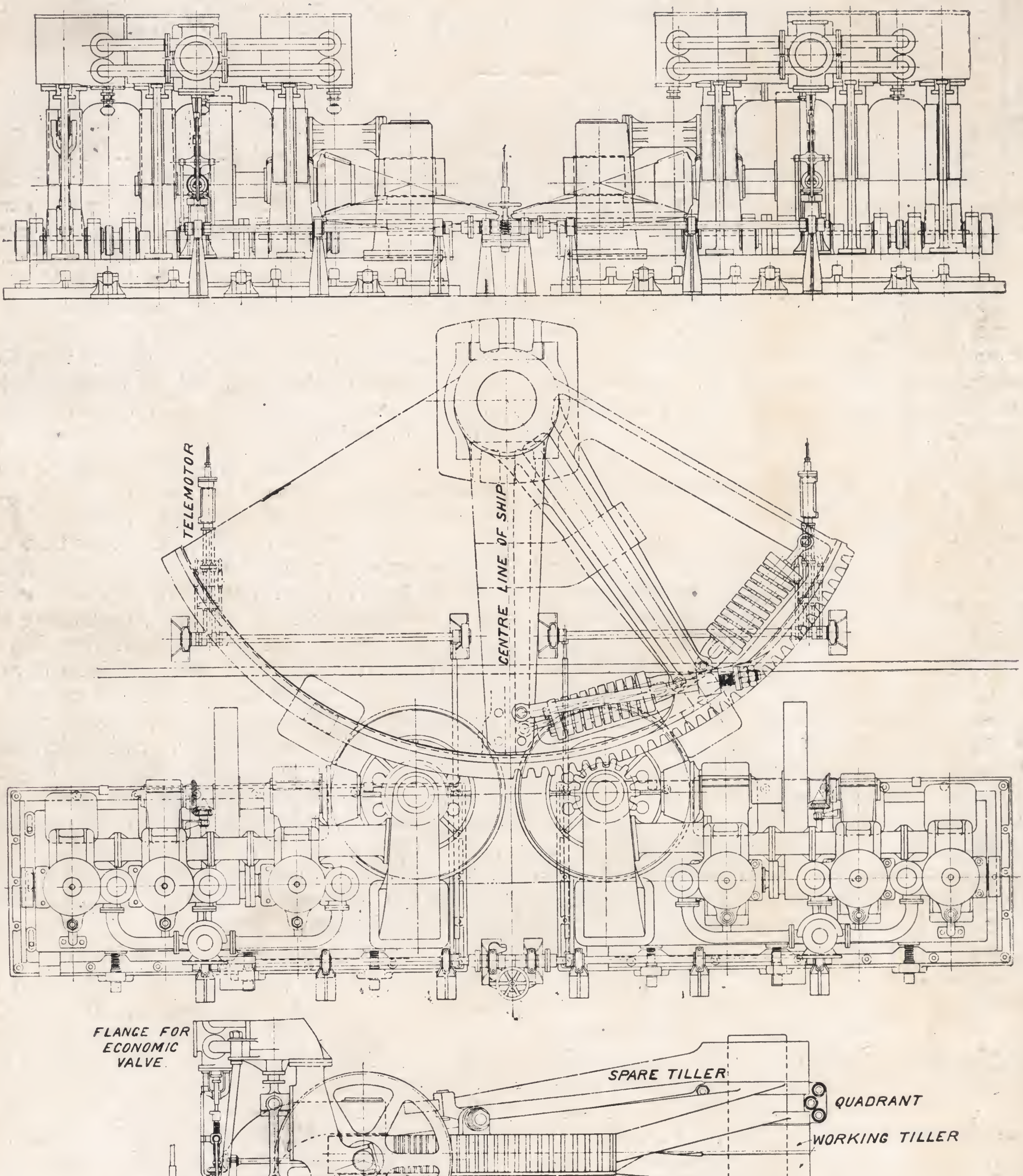
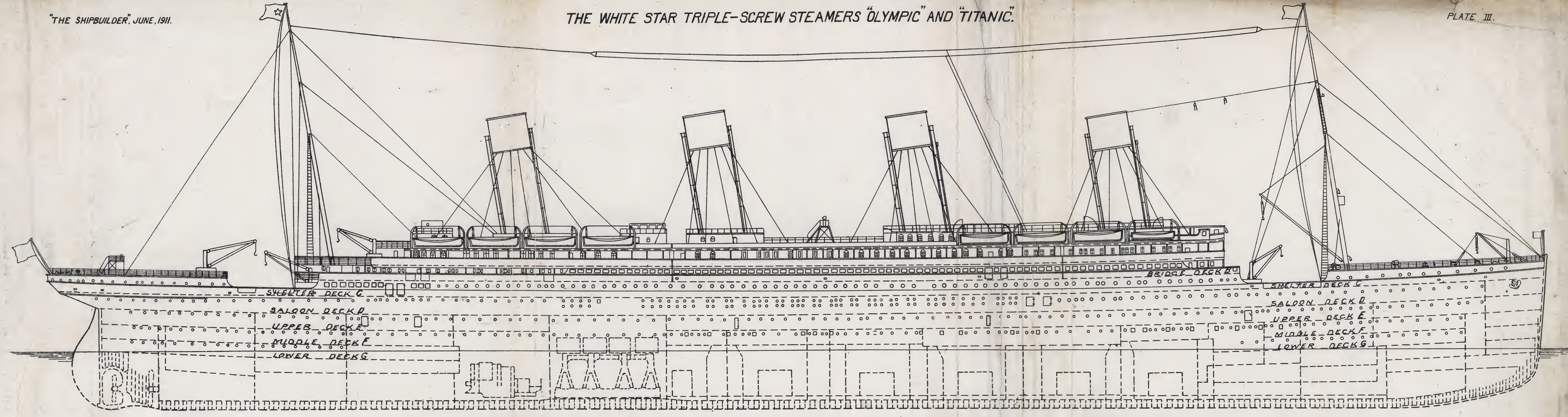
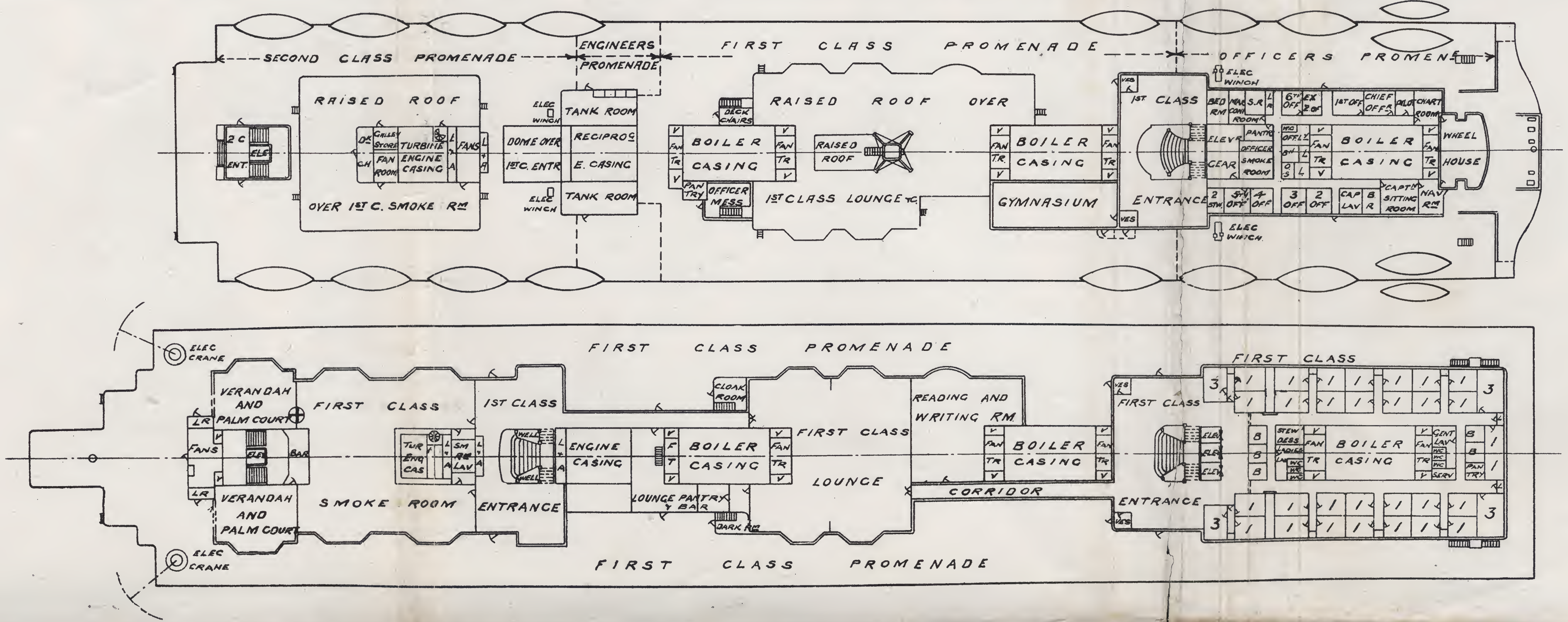


Fig. 139.—Steering Gear.

THE WHITE STAR TRIPLE-SCREW STEAMERS "OLYMPIC" AND "TITANIC."

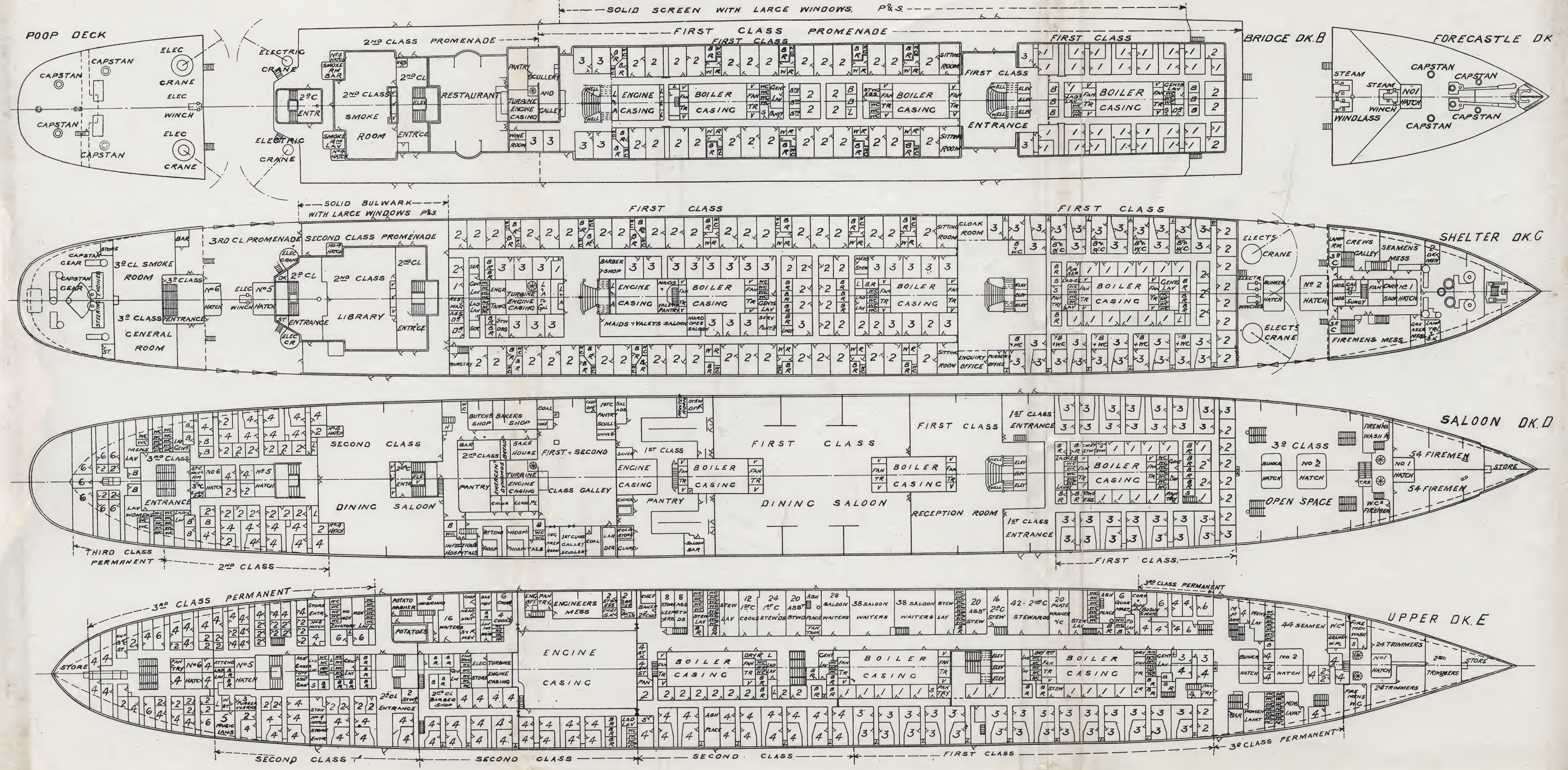




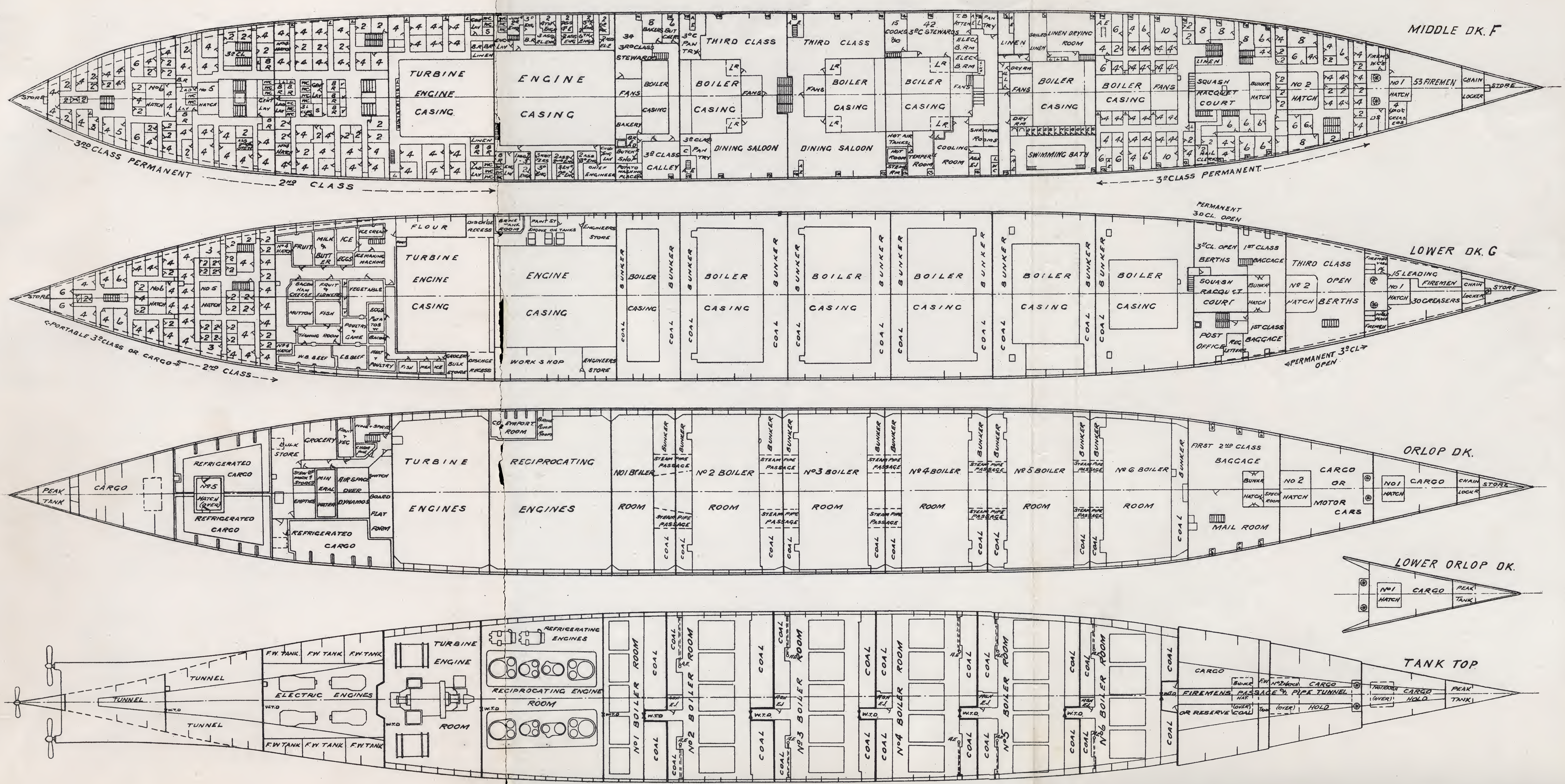
BOAT DECK.

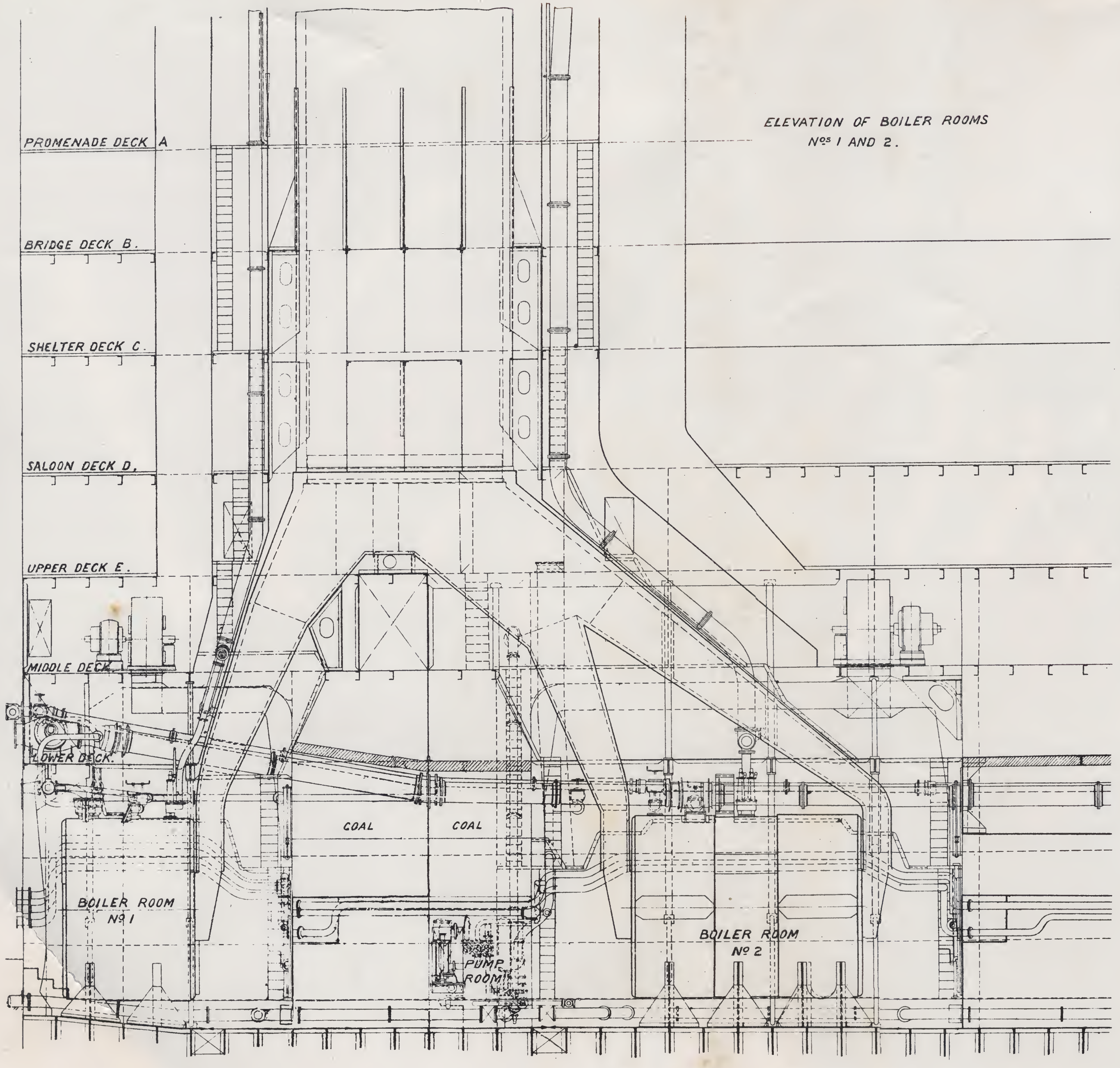
PROMENADE DECK A.

THE WHITE STAR TRIPLE-SCREW STEAMERS "OLYMPIC" AND "TITANIC".

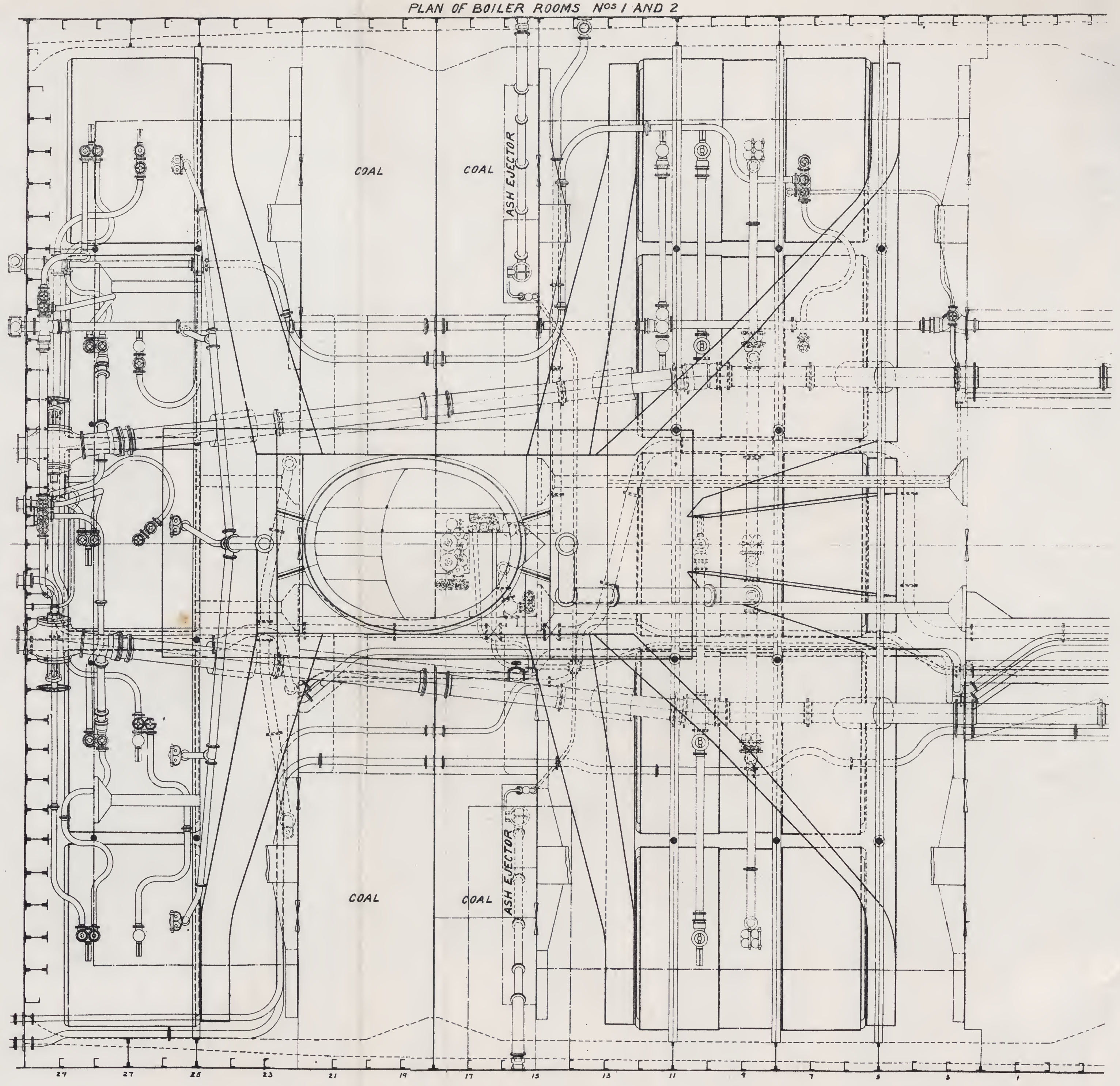


THE WHITE STAR TRIPLE-SCREW STEAMERS "OLYMPIC" AND "TITANIC".



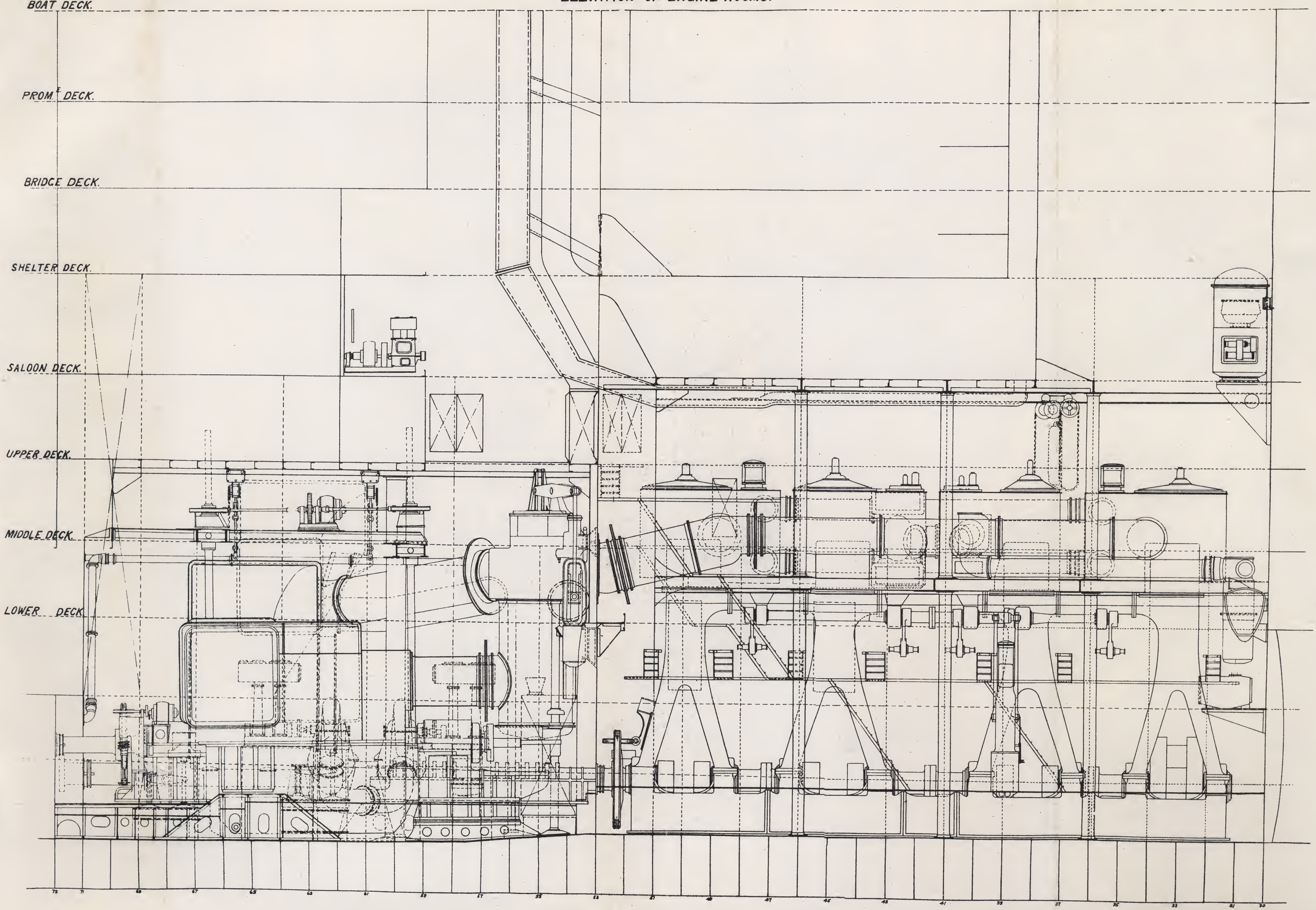


PLAN OF BOILER ROOMS Nos 1 AND 2



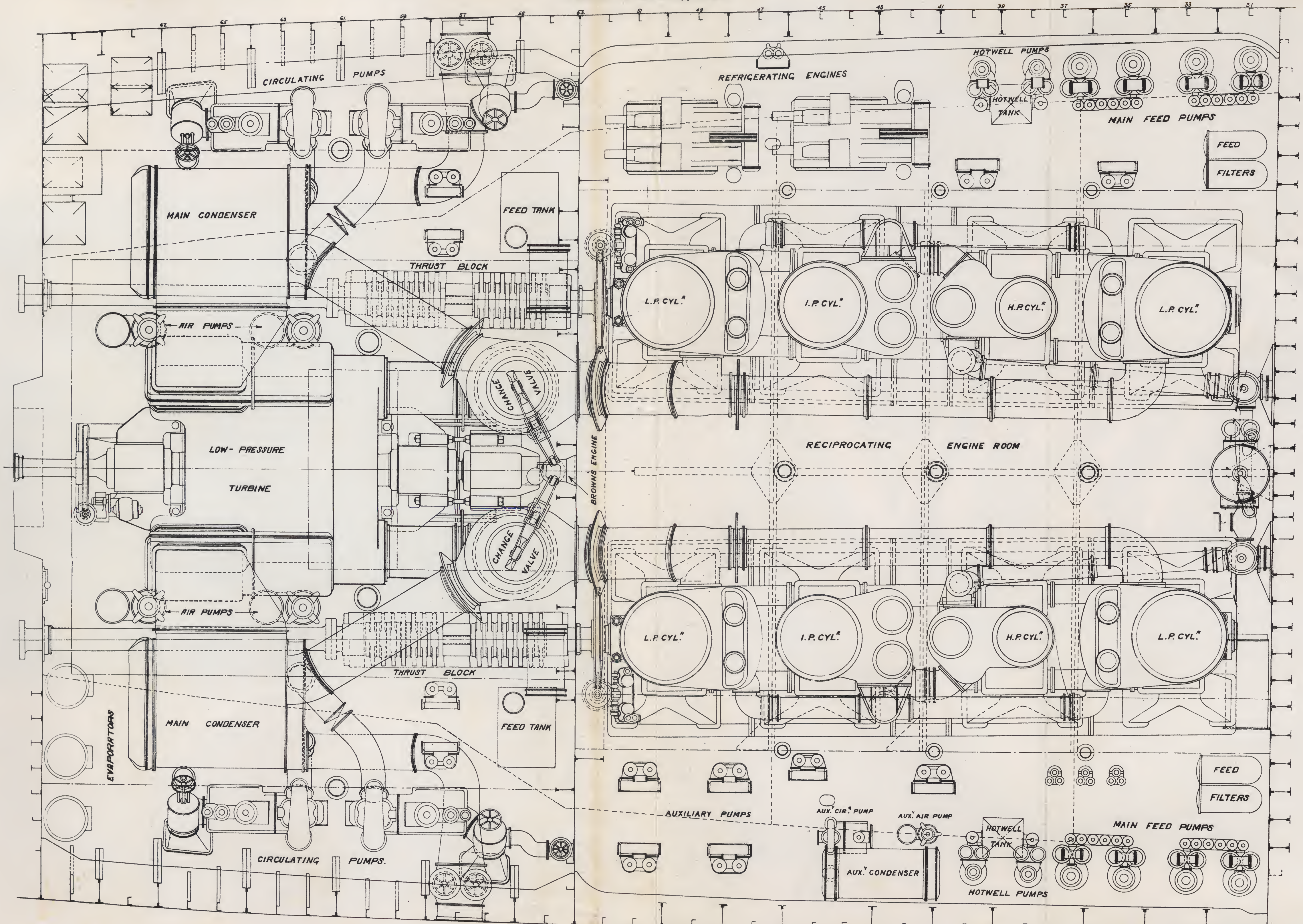
THE WHITE STAR TRIPLE-SCREW STEAMERS "OLYMPIC" AND "TITANIC".

ELEVATION OF ENGINE ROOMS.



THE WHITE STAR TRIPLE-SCREW STEAMERS "OLYMPIC" AND "TITANIC."

PLAN OF ENGINE ROOMS.



the front by three wrought steel columns, and at the back by three cast iron columns, two of the latter also forming supports for the intermediate shaft, which connects the spur and bevel gears. Each engine is so arranged on a sliding bed with adjusting screws that it can be quickly put into or out of gear with the quadrant, when it is desired to change from one engine to the other.

The crank shaft of each engine is provided with a spur-pinion which drives a spur-wheel on the intermediate shaft, carried on the back columns of the engine. This intermediate shaft is connected by bevel gearing to a vertical shaft, which in turn gears into the quadrant by means of a manganese bronze pinion situated above the bevel gearing. The gearing will be better understood by reference to Fig. 139, and is also well shown in the photograph of the engines given in Fig. 140. The spur and bevel gear are of the Citröen type, made of cast steel throughout, and have machine-cut helical teeth of the herring-bone shape, which experience has shown to be the most suitable form for minimum wear when the gears have to transmit power in either direction, as is the case with a steering engine. The sizes of the spur wheels are as follows:—pitch circle diameters, $14\frac{1}{4}$in. and $69\frac{3}{4}$in.; number of teeth, 18 and 87; pitch, about $2\frac{1}{2}$in.; width of face, $9\frac{1}{2}$in. The pitch is given approximately as the Citröen gears are not made to standard pitches. Their noiseless running is mainly obtained through a total absence of back-lash, and this can only be achieved by calculating the exact pitch according to given diameters and a fixed number of teeth. For this reason a special cutter is made for each set of gearing. The sizes of the bevel wheels are:—pitch circle diameters, 5ft. $10\frac{1}{2}$in. and 2ft. $0\frac{1}{2}$in.; number of teeth, 19 and 55; pitch, about $4\frac{1}{4}$in.; width of face, 11in. The teeth on both sides of the face are shrouded to the pitch line, and the total width over the shrouds is $14\frac{1}{2}$in. The weight of each bevel wheel is 1 ton 16 cwt.,

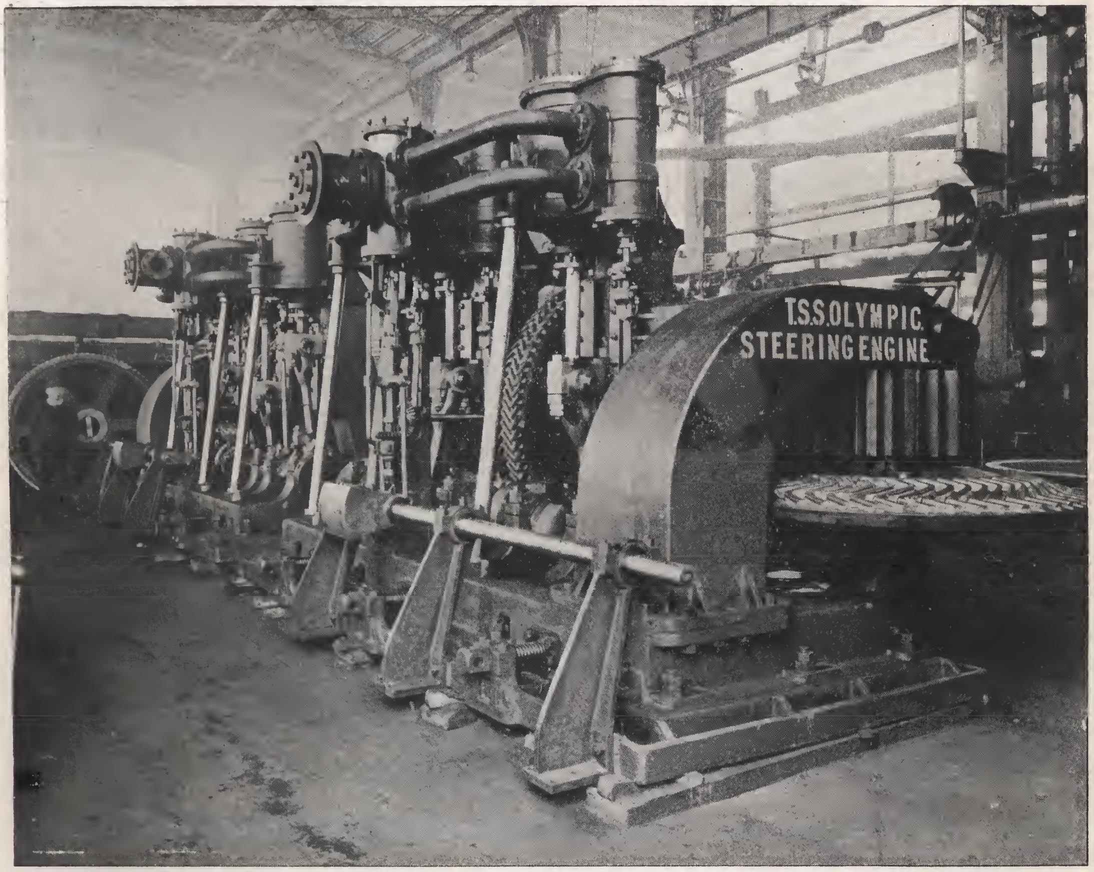


Fig. 140.—Steam Steering Engines with Spur and Bevel Gearing.

and each spur wheel weighs 1 ton 6 cwt. The spur pinion weighs about 5 cwt., and the bevel pinion about 9 cwt. The quadrant and the pinion on the vertical shaft have machine-cut involute teeth.

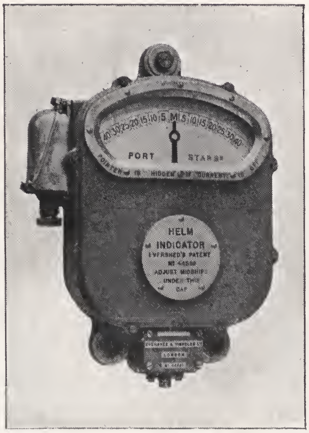


Fig. 141.—Electric Helm Indicator.

The quadrant is connected to the arms of the working tiller by means of heavy spring links, which prevent undue shocks coming upon the gear or the engine. The working tiller consists of two forged arms, one arm being placed at the centre of each half of the quadrant. The tiller arms are keyed to the rudder-head, and are tied together by a strong wrought steel tie-bar. A spare tiller, arranged to come into operation only if the connection between the quadrant and working tiller is disabled, is placed immediately above the quadrant. This tiller can also be worked by the warping capstans should the whole gear be disabled.

The steering gear is controlled from the navigating bridge by Brown telemotors, and from the docking bridge aft by mechanical means. The telemotor cylinders are placed near the steering engines, and are connected by levers and shafting to the steam control valves on the engines. The control valve on each engine is fitted with an economic valve of Brown's type, which shuts off the steam automatically when the engine is at rest, and so prevents the leakage of steam into the cylinder. The precise position of the rudder at any moment is shown by means of an electric helm indicator placed on the navigating bridge. This indicator, which is illustrated in Fig. 141, has been supplied by Messrs. Evershed and Vignoles, Ltd., of London.

Fig. 142.—15½-ton Anchor.

Mooring and Warping Arrangements.

SPECIAL attention has been devoted by the builders to the mooring arrangements of the new vessels. It was realized that a size of ship had been reached for which the usual arrangement of two bower anchors was insufficient, and it was decided to have, in addition to these, a centre anchor worked by a wire rope through the extra hawsepipe in the stem, to which reference has already been made. The centre anchor, which is illustrated in Fig. 142, weighs $15\frac{1}{2}$ tons, and the side anchors each weigh $7\frac{3}{4}$ tons. The cables used in connection with the side anchors are $3\frac{3}{8}$in. diameter and have a total length of 330 fathoms, weighing in all 96 tons. The anchors are of Hall's latest improved type, and, with the cables, have been manufactured by Messrs. N. Hingley & Sons, Ltd., of Netherton, Dudley. A strongly built crane is fitted at the centre-line of the forecastle deck for handling the $15\frac{1}{2}$-ton anchor, which is placed in a well on the deck immediately abaft the stem. The side anchors are housed in the hawsepipes in the usual manner.

The wire hawser used in connection with the centre anchor is $9\frac{1}{2}$in. circumference and 175 fathoms long, and has been supplied, in the case of both the *Olympic* and *Titanic*, by Messrs. Bullivant and Co., Ltd., of London. These hawsers, together with the thimbles and splices necessary, were guaranteed by the makers to withstand a breaking strain of 280 tons. At the request of the Board of Trade, one thimble and splice were tested to destruction at Cardiff in the presence of their surveyor, with the result that the test specimen broke near the tail of the splice at a load of 289 tons.

The introduction of the centre anchor has necessitated an addition to the usual Napier windlass gear in the form of a large grooved drum for winding the $9\frac{1}{2}$-in. hawser mentioned above. This drum, which is placed on the shelter deck right forward, is driven through worm gear by one of the windlass engines. The windlass drums, or cable holders, for winding the cables are placed on the forecastle deck, as shown in Plate IV. and in the view of the forecastle deck given in Fig. 33, page 35. Each drum is mounted upon a vertical spindle, which is carried down to the shelter deck. Upon the lower end of each spindle is keyed a bevel wheel of large diameter, which is driven by worm gearing from one of the vertical windlass engines situated under the forecastle. Clutch-engaging and brake gear has been fitted and every detail embodied to ensure the satisfactory working of the cables under all conditions.

Ample arrangements have been made for warping the vessel in harbour. The forward gear for this purpose consists of four capstan drums placed on the forecastle, and one at a lower level for handling smaller ropes. The two foremost capstan spindles are driven by worm and bevel gearing in a similar manner to that adopted in the case of the windlass drums. The same engines are arranged to perform either of these duties, a system of clutches enabling the windlass drum to be thrown out of gear while the engine is working the capstan drums, and *vice versâ*. The second pair of capstan drums are driven independently by vertical engines placed on the shelter deck beneath them. Similar warping capstans are installed at the after end of the ship. At this end there are five drums with four steam engines, one of which actuates two capstans.

Fig. 143.—Welin Double-acting Boat Davits.

For securing wire hawsers and warps, a large number of mooring bollards have been provided. These bollards are of very large size, as will be seen in the view of the forecastle deck, Fig. 33, referred to above.

Boats and Davits.

THE lifeboats, which are 30ft. long, are placed on the boat deck, as shown in Plate IV. The davits are of the Welin double-acting type manufactured by the Welin Davit and Engineering Co., Ltd., of London. Sixteen sets, specially designed for handling two

or, if desired, three boats each, have been provided. The double-acting system is not altogether new, as it was adopted by another company some time ago in the case of boats carried on the poop, but its employment on such a large scale is a distinct departure. The well-known principle of the Welin davit is retained in all its simplicity, with the addition of a slight segmental increase at the inboard edge of the quadrant. This modification enables the arm to be swung right inboard so that it may plumb the inboard boat, and thereby save the time-wasting operation of shoving and pulling the latter into position, which has to be done with davits of the ordinary type.

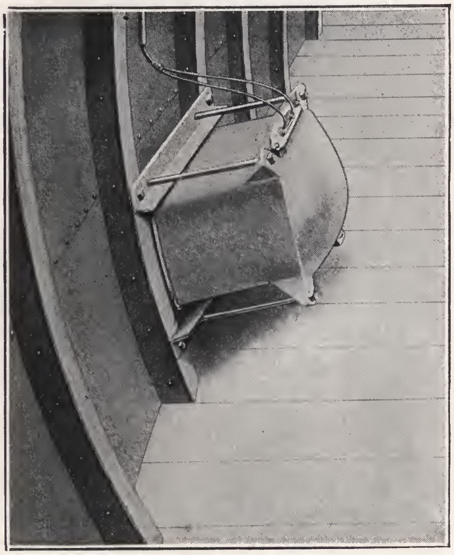


Fig. 144.—Receiving Tank for Submarine Signals.

The arrangement for saving fore and aft deck space is also worthy of notice. Instead of having two separate standards between each boat, the standards are combined in the form of a twin frame; see Fig. 143. The latter carries the two quadrants and all the necessary gear for operating the forward and after boat at will. The operating gear is also of an ingenious and interesting nature. For this purpose a single handle is employed, driving a small pinion, which is mounted upon a swing bar. The latter is thrown into or out of gear by means of a simple eccentric arrangement, which enables either screw of either davit to be worked independently of the other.

For hoisting and lowering the boats, four 15-cwt. electric winches have been provided in the positions shown in Plate III. A description of these winches, which have been supplied by the Sunderland Forge and Engineering Co., will be found in the chapter on the electrical equipment.

Compasses.

The compass outfit consists of four Lord Kelvin's latest patent standard compasses, supplied by Messrs. Kelvin and James White, Ltd. Two of these compasses are placed on the captain's bridge, one on the docking bridge aft, and one on an isolated brasswork platform in the centre of the ship (see Plate III.), which is built up from the boat deck 12ft. above all ironwork and 78ft. above the water-line.

Sounding Machines.

Adjacent to the navigating bridge are two Lord Kelvin's patent motor-driven sounding machines, arranged with spars to enable soundings to be taken when the ship is going at a good speed. The design of the machines is well known, but the latest pattern embodies an improvement in the form of an illuminated dial for night use. The illumination is provided by an electric lamp fitted on the top of the machine. The arrangement is such that the dial rotates, and only the figures adjacent to a pointer on the lamp case are illuminated.

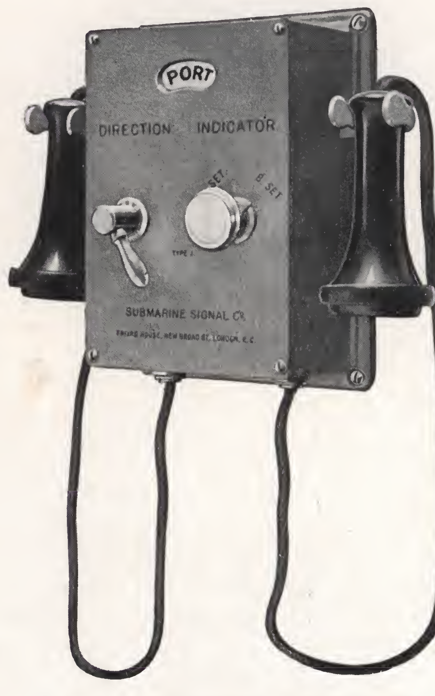


Fig. 145.—Direction Indicator for Submarine Signals.

Submarine Signalling.

Both the *Olympic* and *Titanic* have been fitted with the Submarine Signal Co.'s apparatus for receiving submarine signals. With this system the sound of submarine bells is received through the hull of the vessel. By locating the direction of the sounds, the position of the vessel, when in the neighbourhood of the coast, can be accurately ascertained. The bells are established by the Trinity House and the lighting authorities of the United States, and over 120 are now in operation. The system is a great improvement upon that of aerial fog signals, as the latter, owing to the variations in the density of the atmosphere, are frequently misleading; and water, being constant in density, allows the sound to travel without any interruption at a speed $3\frac{1}{4}$ times greater than its rate of transmission in air.

The signals are received by small tanks containing microphones, placed on the inside of the hull of the vessel on the port and starboard sides below the water level; see Fig. 144. These tanks, which may be termed the "ears" of the ship, are connected to a direction indicator on the navigating bridge (Fig. 145) by ordinary telephonic cable. By moving the switch on the indicator box to port, the port "ear" only is in operation. By changing the switch to starboard, the starboard "ear" commences its work. Assuming the bell to be on the port side of the ship, it is only by that "ear" sounds are received. Should, however, the bell be dead ahead, the sound will be heard equally by both "ears." The signals, therefore, not only give warning of the ship's proximity to a point of danger, but also assist her progress in a fog, as the navigating officer can by their aid tell with more certainty where the ship is located.

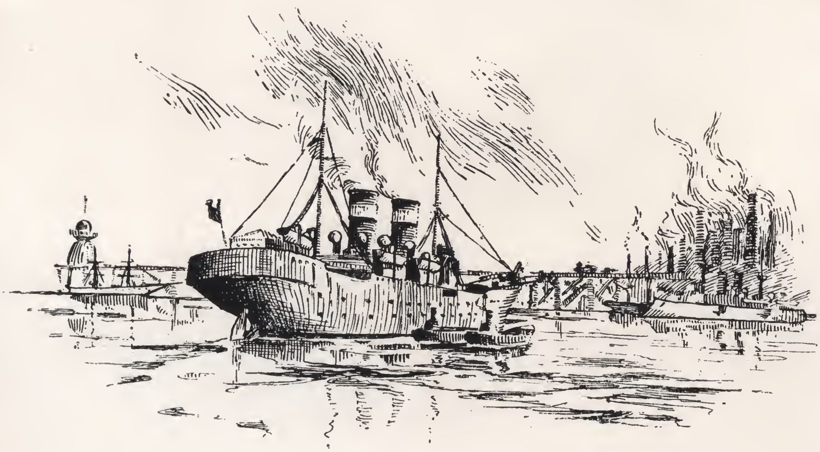


Fig. 146.—The "Olympic" on Trial Trip.

Trials of the "Olympic," and Departure from Belfast.

THE 31st May, 1911, will remain notable in the annals of shipbuilding and shipowning as witnessing the launch of the *Titanic* and the departure from Belfast of the *Olympic*, two vessels which may truly be said to mark an intensely interesting epoch in the history of the mercantile marine. Together they represent an addition to the world's merchant shipping of about 90,000 gross tons and a capital outlay of some three millions sterling, while for the White Star Line there are now waterborne the two largest steamships so far constructed.

Trials of the "Olympic."

ON the 2nd May, the *Olympic* underwent her basin trials, the engines being turned while the vessel was securely moored in the deep-water fitting-out basin, and this preliminary test proved entirely satisfactory. Prior to leaving for her trials at sea, the ship was thrown open for public inspection, and some thousands of visitors paid 5s. each during the first two hours and 2s. for the remaining three hours, the proceeds—a very considerable sum—being handed to the Belfast hospitals.

The *Olympic* took on board 3,000 tons of best Welsh coal for her sea trials, and 250 runners were sent over from Liverpool to assist in the navigation of the vessel. At high water on the morning of the 28th May, the task of swinging the liner was entered upon, the Mersey tugs *Wallasey*, *Alexandra*, *Hornby*, and *Herculaneum*, as well as Messrs. Harland & Wolff's tug *Hercules*, completing the operation without a hitch. On the morning of the 29th May, she proceeded down Belfast Lough to adjust compasses and to carry out her steaming trials, the five tugs just named assisting in getting the ship under way and her departure being witnessed by an immense crowd of spectators.

The sea trials extended over two days, and the results obtained greatly exceeded the expectations of both builders and owners. Statistics with regard to the speed, power, consumption, etc., will not be made public; but it is understood that the designed speed of 21 knots was exceeded, and speeds of $21\frac{1}{2}$ and $21\frac{3}{4}$ knots recorded during the various tests. The new White Star tenders *Nomadic* and *Traffic*, designed for the company's service at Cherbourg and which were completed by Messrs. Harland & Wolff within a month of their launch, were in attendance on the *Olympic* during her trials.

A large party of guests, who had accepted the invitation of the White Star Line to be present at the launch of the *Titanic*, were conveyed from Fleetwood to Belfast by the specially chartered cross-channel steamer *Duke of Argyll*; and as that vessel approached Belfast in the early hours of the 31st May, these visitors had a splendid view of the first of the two great sister ships as she lay in the Lough. The photograph which we reproduce in Figure 146 well illustrates the beautiful lines and stately appearance of the ship. So perfect are her proportions that it is well-nigh impossible for the inexperienced to grasp her magnitude except when seen alongside another vessel.

Departure from Belfast.

THE launch of the *Titanic* having passed off successfully a little after midday, in beautiful weather, the tender *Nomadic* left the quay at Belfast at 2.30 with a small party of representatives of the owners and builders on board, including Mr. J. Bruce Ismay (chairman and managing director of the White Star Line), Lord Pirrie (head of the firm of Harland & Wolff), Mr. J. Pierpont Morgan (who travelled specially from London to witness the launch of the *Titanic*), and Mr. Harold Sanderson and Mr. H. Concanon of the White Star Line, to join the *Olympic*. The liner sailed for Liverpool at 4.30 p.m. on the 31st May, having thus been completed and handed over to her owners twenty-nine months after the laying of the keel, and seven months and eleven days after her launch.

The *Olympic* arrived off the Mersey on the 1st June, and was again thrown open for public inspection. She left Liverpool on the same evening for Southampton, to prepare for her maiden voyage to New York, calling at Cherbourg. While in Southampton the vessel was visited by some thousands of people, prior to sailing with a full complement of passengers on the 14th June.

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